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Molluscan Research

(Formerly Journal of
The Malacological Society of Australia)

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(Formerly Journal of The Malacological Society of Australia)

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Announcements

Molluscan Research

The Malacological Society of Australia has been evolving during the forty years of its existence. In recent years there has been increased emphasis and membership of the Society in New Zealand and countries to the north of Australia. In recognition of its changing role the Society changed its name to the Malacological Society of Australasia at the annual general meeting held in Sydney in November 1993.

With the change in name and emphasis of the Society a re-examination of the role of the *Journal of the Malacological Society of Australia* was appropriate. After extensive discussion within the MSA Council it was decided to broaden the content of the *Journal* and change its name to *Molluscan Research* to reflect the modifications. The cover and pages have been redesigned. To ensure continuity the volume numbering remains the same.

Theoretical papers considering any molluscan topic are welcome for consideration for publication in *Molluscan Research*. Papers concerning specific geographical areas or new taxa should be restricted to the Indo-West Pacific region. If sufficient papers are available *Molluscan Research* will appear twice a year.

Indo-Pacific Malacological Meeting

A second major change to the Malacological Society of Australasia is the intention of holding a mollusc symposium in Australia every two to three years. The first such meeting will be held in Sydney in July 1995 in conjunction with the annual conference of the Australian Marine Sciences Association. Further information will appear in upcoming issues of *Australasian Shell News.*

The MSA Council has also agreed to hold an international meeting on molluscs of the Indo-Pacific region in Perth, Western Australia, in January or February 1997. This notice is intended to alert malacologists worldwide of the upcoming meeting and to solicit to suggestions for possible symposia; all suggestions of possible topics are welcome. The meeting will include all aspects of malacology, including molluscs of marine, freshwater and terrestrial habitats. If sufficient interest develops a postconference field trip to the southwest of Western Australia can be arranged. To be placed on the list for direct receipt of future notices please write: Dr. F.E. Wells, Western Australian Museum, Perth 6000, Western Australia (Fax: 61–9–328–8686).

Moll. Res. 15: 3–11 (1994).

The Chinese viviparid snail *Bellamya heudei guangdungensis* (Kobelt, 1906) in Australia (Prosobranchia: Viviparidae)

Michael Shea

c/- 16 Belmont Parade, Mt. Colah, New South Wales 2079

The Chinese viviparid snail *Bellamya heudei guangdungensis* (Kobelt, 1906) is recorded from Australia for the first time. Its identity is clarified to avoid confusion with a similar Asian species *Angulyagra polyzonata* (Frauenfeld, 1862). Illustrations and notes on both species are presented.

Key words: *Bellamya*, Australia, Viviparidae

Introduction

The Viviparidae[1] is a family of medium to large sized freshwater, ovoviviparous, prosobranch snails found in most temperate and tropical areas except South America. In Australia viviparids are distributed across northern, central and south-eastern inland areas as far south as the Murray River. These comprise three genera – *Larina* A. Adams, 1854; *Centrapala*, Cotton 1935 (=*Larina*?) and *Notopala* Cotton 1935. *Notopala* is the only indigenous genus found in New South Wales, being restricted to the Murray-Darling drainage basin inland from the Great Dividing Range with a single exception from the lower Hunter River drainage near Cessnock on the central east coast. (Fig. 1). The appearance of a Chinese viviparid *Bellamya heudei guangdungensis* (Kobelt, 1906) in the Lane Cove River and Centennial Park in Sydney is the first known occurrence of an exotic viviparid in Australia. This species has a confused taxonomic history and consequently, is described in detail below.

Taxonomy

Bellamya heudei guangdungensis (Kobelt, 1906)

Vivipara (*quadrata* var.) *heudei* [var. *guangdungensis*] Kobelt, 1906: 124–125; pl. 21, figs. 12–13.

Dactylochlamys quangdugensis [sic] Prashad, 1928: 169.

Viviparus polyzonatus Yen, 1939: 37, pl. 3, figs. 14–15. (Holotype and paratype of *V. q. guangdungensis*)

Angulyagra quangdugensis (Kobelt, 1907) [sic] Yen, 1943: 128.

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[1] *Notopala*, *Bellamya* and *Angulyagra*, belong to the viviparid subfamily Bellamyinae. Sitnikova and Starobogatov (1982) elevated this subfamily to family status. This is not followed here.

Sinotaia polyzonata Zilch, 1955: pl. 6, fig. 52 (Holotype of *Viviparus heudei guangdungensis*).

'Vivipara' quadrata guangdungensis Brandt, 1968: 219.

Sinotaia quadrata guangdungensis Brandt, 1974: 30.

Bellamya heudei Liu, 1991: 587.

Previous studies

Bellamya heudei guangdungensis has had a confused taxonomic history. Kobelt (1906) first introduced *guangdungensis* as a strongly ribbed form of *Vivipara heudei* (which itself was described as a variety of the species *quadrata*) from Guangdong province in China. Subsequently *guangdungensis* was given full species status by Prashad (1928) and mis-spelt *quangdugensis*. Yen (1939) placed *guangdungensis* in the synonymy of *Viviparus polyzonatus* but later reinstated it (1943), without explanation, once again as a full species. Zilch (1955) figured the holotype of *guangdungensis* under *Sinotaia polyzonata* apparently unaware of Yen's (1943) paper. Brandt (1968, 1974) referred to *guangdungensis* as a 'race' of species *B. quadrata*. Liu (1991) recognized *heudei* as a distinct species but did not recognize *guangdungensis* as

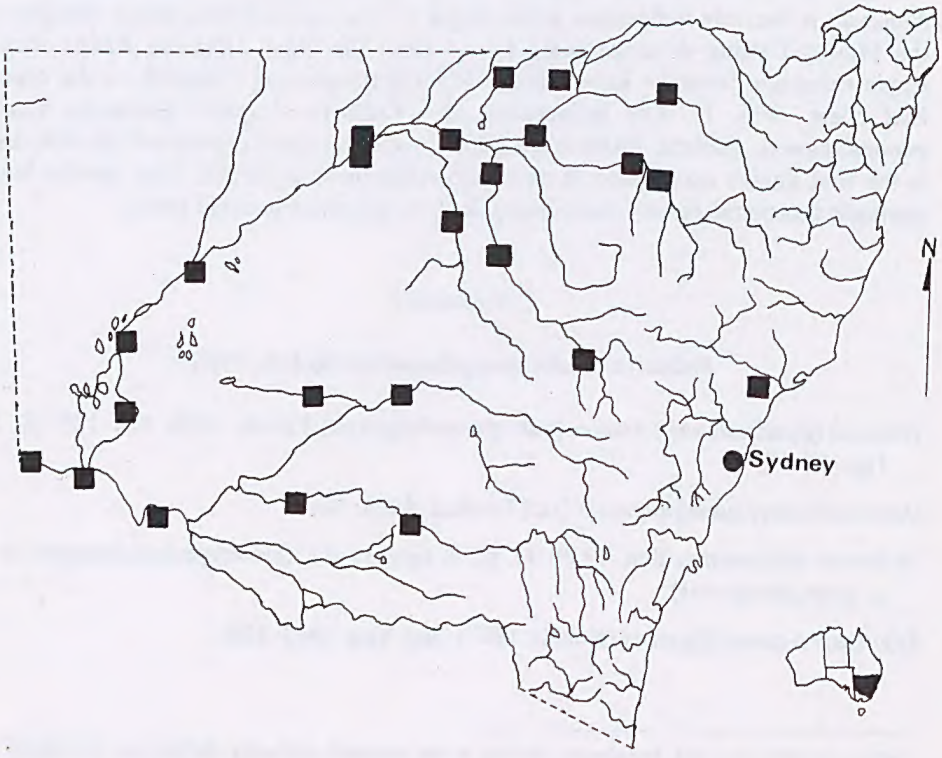

Figure 1. Distribution of Viviparidae in N.S.W. ■ *Notopala*; ● *Bellamya*.

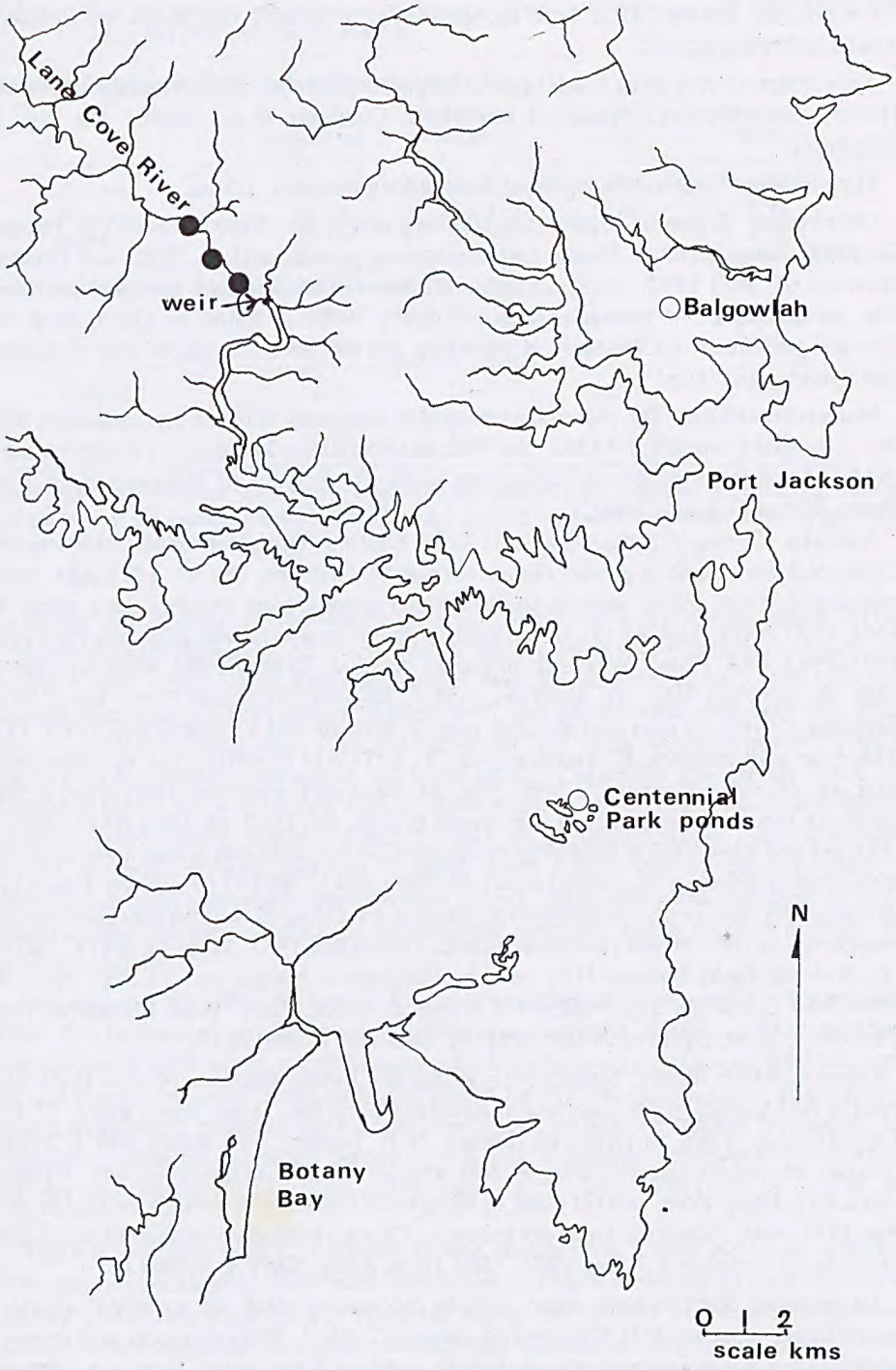

Figure 2. Distribution in the Sydney area of *Bellamya heudei guangdungensis* (Kobelt, 1906). ● Living population; O Former occurrence.

taxonomically distinct. It is here recognized as a distinct subspecies of *Bellamya heudei* following Kobelt.

Type material: *Bellamya heudei guangdungensis* (Kobelt, 1906). Museum of Natural History, Senckenberg, Frankfurt am Main, Germany (Cat. 38890) see Fig. 3a (holotype).

Type locality: Canton (Guangzhou), Guangdong Province, China.

Distribution: *Bellamya heudei* (Dautzenberg & Fischer, 1905) is found in Jiangsu, Zhejiang, Jiangxi, Hubei, Hunan and Guangdong provinces (Liu, 1991) and Guangxi province (A. Roll 1992., pers. comm.) in eastern China, Vietnam and possibly Laos. The subspecies *B. h. guangdungensis* (Kobelt, 1906) is found in Guangdong and Guangxi provinces in China and Hong Kong and has been introduced into Singapore and Sydney, Australia.

Material examined: The material examined in this study is based on collections from the Australian Museum (AM); the Naturhistorisches Museum, Vienna, Austria (NMVA) and from the private collections of Mr O. Griffiths of Mauritius (OGC) and Dr. A. Roll of Germany (ARC).

Australia (Sydney): Balgowlah: coll. G.P. Whitley, Dec. 1939 AM C.300197 (4); Centennial Park: lake at Anzac Parade corner, O. Griffiths, 28 Oct. 1973 AM; under submerged wood and in sand in shallow water around edge of large duck pond, M. Shea, 1973 AM C.158281 (5); in mud and on palm fronds in lake opp. lyly (sic) pond 1973–1982, OGC (20+); West side of Parkes Avenue, 20 May 1982, stranded alive on edge of southern lake, O. Griffiths AM C.300196 (4); Lane Cove River State Recreation Area: on river surface after rain, B. Jenkins and V. Morrissey, 2 Oct. 1978 AM; near park entrance, E. Rudman, Feb. 26, 1979 AM C.300192 (3); upstream from weir, on submerged wood, 22 Sept 1991, M. Shea AM; upstream from weir, a large colony in cracks and crevices of submerged branch, Jan 1992, M. Shea AM C.300194 (13); Jan and May 1992 at Half Way Point and Cottonwood Glen picnic areas upstream from weir in debris on shoreline (dead), M. Shea AM C.300193 (5); Lower Lane Cove River (empty shells only): off Mowbray Road, Lane Cove, in drift on shoreline beneath mangroves at edge of war memorial athletic field, Dec. 1983, M. Shea, AM C.300195 (1); Boronia Park, Hunters Hill, on shoreline behind mangroves, 15 Sept 1991, M. Shea AM C.300199 (1); bottom of Swaines Creek, O.H. Reid Memorial Park, Chatswood West, Sydney, 14 Dec 1981, M. Shea AM C.300198 (1).

Other material: Jurong, Singapore, lilypond in Chinese gardens, 19 Sept 1979, D.P. Fairfax AM C.302314 (9). Lam Tsuen River at Chung Uk, Tsuen, Hong Kong, 22°27'N 114°08'E, Apr 1983, in river and ditches, W.F. Ponder, AM; Japan AM C.302315 (2),(this record is questionable as this species is not recorded in any Japanese literature); Hong Kong market (said to have been collected in neighbouring China) 5 Apr 1977, ARC. Nanning, Guangxi province, China, floating on surface of small pond inside hotel compound, 3 May 1982, ARC. Hong Kong, NMVA, 68038(2).

Description: Shell ovately conic, thin to moderately thick, up to seven whorls in adults (spire often eroded). Dimensions given in Table 1. Whorls convex and rounded, slightly shouldered near suture and slightly angulate at periphery. Sutures moderately indented. Base moderately deep and rounded, umbilicus absent. Juvenile shells

Table 1. Shell and aperture measurements of *Bellamya heudei guangdungensis* (Kobelt, 1906) from Centennial Park and Lane Cove River.

Centennial Park population. 8 adults measured (AM, OGC)

	Shell Length (mm)	Shell Width	Aperture Length	Aperture Width
Largest	28.34	19.00	13.50	10.00
Smallest	18.10	13.00	10.00	7.35
Mean	24.14	16.90	11.80	8.91

Lane Cove River population. 16 adults measured (AM, ARC)

	Shell Length	Shell Width	Aperture Length	Aperture Width
Largest	24.70	17.40	12.53	9.60
Smallest	18.45	13.80	9.75	7.30
Mean	21.19	15.60	11.50	8.91

Adult shells are considered those with the inside of the aperture edge thickened, the columella reflected and the base of the aperture rounded. Juveniles lack aperture edge thickening and a reflected columella. The base of the aperture is angled.

turbinate with acutely angled whorls, smooth except for a few spiral striations (Fig. 3d). Spiral keels beginning on fourth whorl, usually three above periphery, fourth just below suture weak. Spiral keels and cords variable below periphery, but generally weaker than above. Shell surface marked with fine growth lines and very fine spiral striations between each keel. Aperture sub-ovate, but often faceted because of keels, slightly to moderately thickened inside in adults. Columella moderately thick and reflected. Umbilical area glazed. Colour olive green to olive brown; keels dark brown; aperture bluish white within; columella pink to yellow or white, edge often dark brown. Juveniles pinkish merging to apple green. Operculum translucent orange to dark brown with concentric growth lines. Head, neck, foot and tentacles of living animal pale blue-grey covered in salmon-pink speckles, based on 80+ juvenile and adult specimens.

Comparative remarks: *Bellamya heudei guangdungensis* is readily distinguished from the indigenous viviparid genera found in Australia. *Notopala* have relatively smooth shells without the strong raised keels characteristic of *Bellamya*, whereas shells of *Centrapala* (=*Larina*?) and *Larina* differ in having finer spiral cords when present and having more bulbous whorls and low spires similar to marine Naticidae. The Australian material examined agrees with Kobelt's original description and with the figures and photographs in Zilch (1955: pl.6, fig. 52) and Yen (1939: pl. 3, figs. 14–15).

There is a large complex of spirally ribbed viviparids in China and south-east Asia. The true relationships of these many forms has still to be evaluated as most species are known from only their shells, many of which are similar. For example *Bellamya heudei guangdungensis* has been confused with another spirally ribbed Asian species, *Angulyagra polyzonata* (Frauenfeld, 1862). Both species are similar and until comparative anatomical, molecular and electrophoretic studies are carried out, the true

Table 2. Measurements of *Angulyagra polyzonata* (Frauenfeld, 1862).

Source	Shell Length (mm)	Shell Width	Aperture Length	Aperture Width
Frauenfeld 1862	29	19.5	14	10
Kobelt 1906	33	22	—	—
Yen's 1939 lectotype	29.10	20.20	15.10	11.90

status of each will remain problematic. However the much stronger ribs and slightly larger size of *A. polyzonata* distinguish it from all of the specimens of *Bellamya heudei guangdungensis* the author has seen (Table 2).

Remarks – Type material of *A. polyzonata*. The lectotype of *A. polyzonata* 68037 (Fig. 3f) is illustrated with two paralectotypes 68038 (Figs. 3g and 3i). These two lectotypes are in fact *Bellamya heudei guangdungensis*. Only one of the seven labels accompanying the two paralectotypes bore a locality, it read '*Paludina angularis* Mke, Hong Kong'. The lectotype of *A. polyzonata* bore no locality data, but Yen, (1939: 37), listed China as 'Locus typicus' and again in 1943 (p. 128) as '(Canton) China'. The three specimens numbered as 68039 in the NMVA catalogue and labelled 'Philippine Islands' have not been seen by the author. This locality was questioned by Bartsch (1909: 365) in reference to this species. Frauenfeld (1862: 1165–1166) apparently did not list a locality in his original description of *A. polyzonata*. Kobelt (1906: 142,417) recorded *A. polyzonata* from Annam (Trung Phan), Hanoi and Cao Bang in Vietnam. Lui (1991: 592) recorded *A. polyzonata* from Guangdong and Hainan in China.

Discussion

Bellamya heudei guangdungensis is the first known exotic viviparid to establish colonies outside aquaria in Australia. At present the species is restricted to the Lane Cove River in the Sydney metropolitan area of central eastern New South Wales. The indigenous *Notopala* spp. in New South Wales are restricted to the Murray-Darling drainage basin west of the Great Dividing Range with a single exception from 'Bow Wow Gorge' near Cessnock in the coastal lower Hunter drainage (Fig. 1). Sheldon and Walker (1993) noted that *Notopala* is apparently almost extinct in the Murray Darling Basin. The 'Bow Wow Gorge' *Notopala* population, which have strongly banded shells, is apparently still extant (F. White, pers. comm. 1993).

Bellamya heudei guangdungensis lives in similar situations to other viviparids and can be found attached to submerged wood, sometimes in large aggregations, in cracks, crevices and under loose bark, or ploughing through sand or mud on the river or pond bottom and often floating on the water surface, sometimes in large numbers (G. Clark, pers. comm.). Dead shells are usually encountered in debris on the river edge or its estuary, often with operculum still in place and juvenile shells in various stages of development within.

The range of *Bellamya heudei guangdungensis* in Sydney has declined. The author could not find any snails on several visits to Centennial Park in 1991 and 1992. The species had been very common in Busby's Pond (the pond referred to on all locality

Figure 3. Shells of *Bellamya heudei guangdungensis* (Kobelt, 1906) and *Angulyagra polyzonata* (Frauenfeld, 1862). a) Holotype of *Bellamya heudei guangdungensis* Museum of Natural History, Senckenberg, Frankfurt, Germany (38890, Canton China). Reproduced from Zilch, 1955. Shell length 26mm. b) *B. h. guangdungensis*. Lane Cove River State Recreation Area, May 1992. AM C.300194. Shell length 21 mm. c) *B. h. guangdungensis*. Centennial Park, Sydney, 1973. AM C.158280. Shell length 25.5 mm. d) *B. h. guangdungensis*. Centennial Park, Sydney, 1973. AM C.158280 (juvenile). Shell length 7.4 mm. e) *B. h. guangdungensis*. Centennial Park, Sydney, 1973. AM C.158280. Shell length 22 mm. f) Lectotype of *Angulyagra polyzonata*. No locality, NMVA 68037. Shell length 29.10 mm. g) Paralectotype of *Angulyagra polyzonata* (=*Bellamya heudei guangdungensis*) NMVA 68038. Shell length 25 mm. h) *B. h. guangdungensis*. Centennial Park, Sydney. 1973–1982. OGC. Shell length 18.10 mm. i) Paralectotype of *Angulyagra polyzonata* (=*Bellamya heudei guangdungensis*). NMVA 68038. Shell length 28.34 mm. j) *B. h. guangdungensis*. Centennial Park, Sydney. 1973–1982. OGC. Shell length 28.34 mm.

data) during the 1970s and apparently was not found in any of the other ponds in Centennial Park. The last Centennial Park record was on 20 May 1982. The cause of its disappearance is not known. Of the eight species of aquatic molluscs the author collected in the early 1970s in the Centennial Park pond systems only three could be found in 1991/92. *Bellamya* still occurs in reasonable numbers in Lane Cove River upstream from the weir.

The exact locality of G.P. Whitley's Balgowlah record of 1939 – the first specimens collected in Australia – is not known. The author could find no specimens in Manly Dam at North Balgowlah in 1991, the most likely locality in the Balgowlah area. Possibly Whitley's specimen came from an aquarium or garden pond. The species is easily kept in captivity. Two specimens collected and kept in an aquarium survived about 16 months (G. Clark, pers. comm.).

The introduction of *Bellamya heudei guangdungensis* is of little concern at present considering its very limited and declining range and natural absence of indigenous viviparids where it now occurs. However, if it were to spread to waterways where native viviparids do occur, it may possibly pose a threat through competition, particularly in tropical areas with permanent water bodies.

Acknowledgements

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Two new *Rissoina (s.s.)* sister species from the Western Pacific

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Two new species of *Rissoina (Rissoina)* from the tropical western Pacific are named and their shells described. Both species seem to be closely related to each other differing mainly in protoconch characters and in larval development. No other similar species are recorded so far.

Key words: *Rissoina*, Rissoininae

Introduction

In the course of a more detailed revision of the subfamily Rissoininae (family Rissoidae), currently in progress, two very similar Pacific species were recorded. Both show considerable similarities in teleoconch characters, but differ in protoconch features. It is suggested here that they represent a species pair. Determining species pairs, however, is difficult if: (1) several species of a particular group are very similar (as in the case of groups with little inter-specific variation) or (2) if sister species evolve rapidly and differ in several features. Identification of sister species relationships should be based essentially on synapomorphies (Panchen, 1992).

Rissoininae species do not differ markedly from each other in anatomical features, other than penial morphology, and therefore species identification is usually based on shell characters only (Ponder 1985; Sleurs, 1993). However, the latter seem to be strongly subject to parallelism, which makes identification of the apomorphic conditions extremely difficult. Nevertheless, if a particular complex sculpture pattern is observed in only two species of the same supraspecific taxon, then, in the absence of other conflicting data, this can be used as justification for relationship.

Abbreviations

AMS: Australian Museum, Sydney; KBIN: Koninklijk Belgisch Instituut voor Natuurwetenschappen, Brussels; LACM: Los Angeles County Museum of Natural History, Los Angeles; NNML: Nationaal Natuurhistorisch Museum, Leiden

Systematics

Family Rissoidae Gray, 1840

Subfamily Rissoininae Stimpson, 1865

Genus *Rissoina* d'Orbigny 1840

Subgenus *Rissoina*

Rissoina (Rissoina) vangoethemorum sp. nov.

(Figs. 1 A–D; 3)

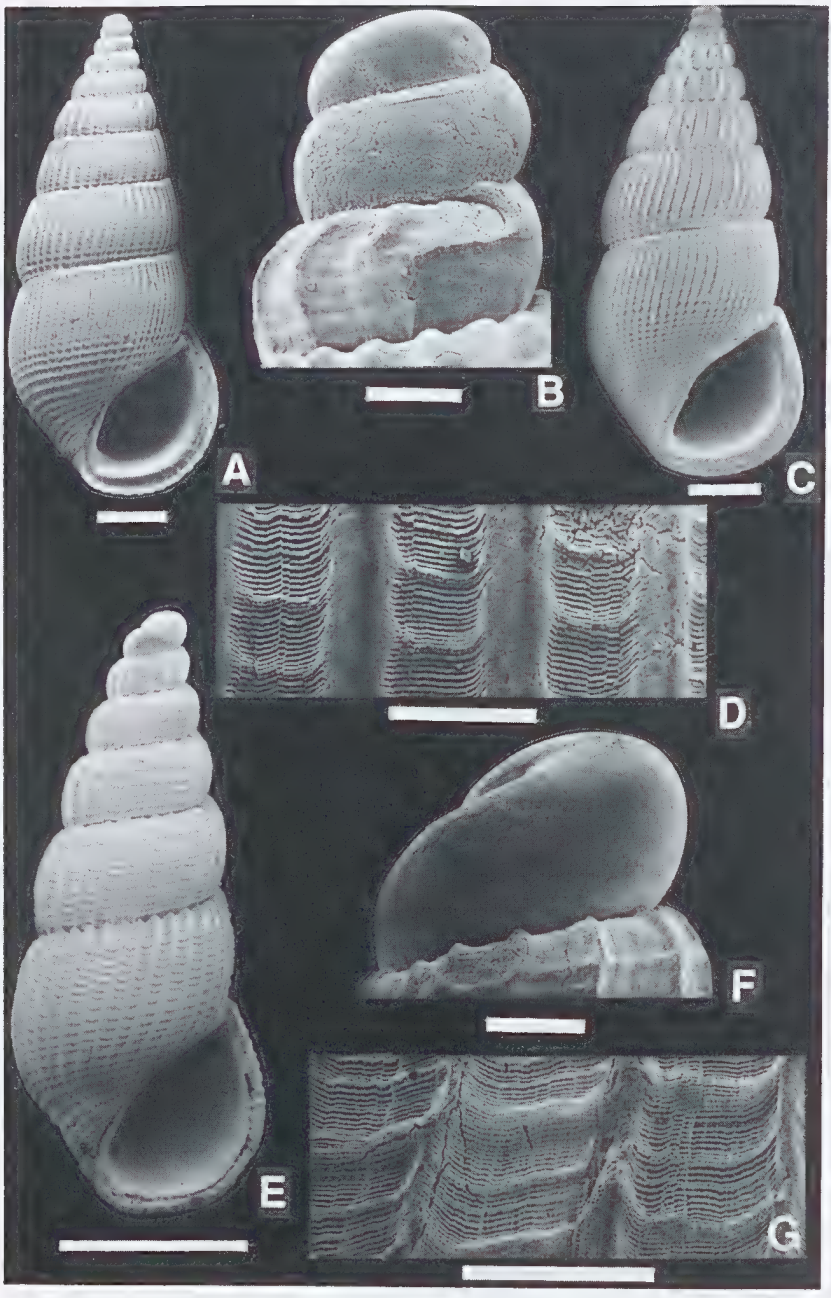

Figure 1. A–D. *Rissoina* (*Rissoina*) *vangoethemorum* sp. nov. A–B, D. Holotype of *Rissoina* (*Rissoina*) *vangoethemorum* sp. nov., Reamuna Islet, Madang Province, Papua New Guinea (KBIN). A. Shell (scanning electron micrograph). C. Lifou, New Caledonia (Coll. Dautzenberg, KBIN). E–G. *Rissoina* (*Rissoina*) *soror* sp. nov. 1 km N.N.W. of Oku, Okinawa, Japan (LACM, 77–61). E. Shell (scanning electron micrograph). F. Protonconch (scanning electron micrograph). G. Microsculpture of teleoconch (scanning electron micrograph). (Scale bars: E: 1 mm; A, C: 0.5 mm; B, D, F–G: 0.1 mm).

Type material: Holotype (Fig. 1 A–B, D): empty shell from Reamuna Islet (04°17'S, 144°59'E), Madang Province, Papua New Guinea, reef flat at very low tide, at the underside of coral boulders, coll. J. Van Goethem, L. Vanderborght, B. & R. Van Goethem, 03.VI.1981 (stn. PNG 81–251) (KBIN, 463). Paratypes: one empty shell from the type locality (PNG 81–251) (KBIN), one empty shell from Reamuna Islet (Madang Prov.), Papua New Guinea, reef flat at very low tide, at the underside of coral boulders in the intertidal zone, 31.VII.1981, coll. M. Magap (PNG 81–543) (KBIN); one empty shell from off Murray I. (09°56'S, 144°04'E), Torres Strait, Queensland, 30.VIII–03.X.1907, coll. C. Hedley (AMS, C.154018).

Description: Shell (Fig. 1 A, C): small (length up to 4.7mm), elongately conical, rather thin. Protoconch (Fig. 1 B): elongate, subcylindrical, of planktotrophic larval type, of 1 3/4, moderately convex whorls, with deeply impressed suture; surface smooth, apart from one weak subsutural spiral thread on last whorl; transition to teleoconch abrupt with deep and narrow adapical sinusigeral notch, latter with weakly thickened margin. Teleoconch: of about 6–7, weakly convex to almost flat-sided whorls; adapical spire whorls moderately depressed (much wider than high); sutures deeply impressed to narrowly channeled; sculpture of prominent, rounded, distantly to densely spaced, almost orthocline to weakly opisthocline axial ribs, the latter more densely spaced, more numerous and less prominent on abapical whorls; axial ribs of last whorl very weak to almost absent on abapical half of last whorl; interspaces on 3–4 adapical whorls moderately wide, moderately deep and gradually narrower and shallower on subsequent whorls; early spire whorls with moderately prominent, distantly spaced, rounded spiral riblets, overriding the axial ribs; spiral sculpture gradually weaker, more densely spaced and more numerous on subsequent spire whorls; spiral sculpture more prominent on abapical half of last whorl, forming very weak, rounded nodules where intersecting abapical part of axial ribs. Microsculpture (Fig. 1 D) of very fine, densely spaced, spiral threads between spiral riblets. Aperture: lenticular; inner lip weakly angulate centrally, thin and narrow; anterior channel absent; outer lip thin, moderately opisthocline, with a very narrow, weakly thickened and rounded, external

Table 1. *Rissoina (Rissoina) vangoethemorum* sp. nov. Shell dimensions (L: total shell length; Ls: spire length; D: shell diameter; no. whorls: number of teleoconch whorls).

	L (mm)	Ls (mm)	D (mm)	no. whorls
Holotype: Reamuna Islet, Papua New Guinea (KBIN)				
Fig. 1 A–B, D	4.24	2.74	1.72	7
Paratypes: Reamuna Islet, Papua New Guinea (KBIN)				
	4.08	2.58	1.69	6 1/2
	?3.76	?2.30	1.63	6
Paratype: Murray I., Queensland, Australia (AMS, C.154018)				
	4.66	3.00	1.98	6 3/4
Indonesia, Ambon (NNML)				
Stn 44	4.03	2.53	1.72	6 1/2
Stn 30	3.38	2.19	1.44	5 3/4

varix, the latter bearing several, densely spaced axial and spiral riblets, giving outer lip a slightly crenulated appearance. Colour: white throughout. Operculum, radula and internal anatomy: unknown.

Shell dimensions: See table 1.

Additional material examined: INDONESIA: Ambon: Hitu, Suli, 6m, Rumphius Biohistorical Expedition, 1 spec. (NNML); Leitimur, Latuhalat, Rumphius Biohistorical Expedition, 1 spec. (NNML). AUSTRALIA: Queensland: Heron I., Capricorn Group, 6m, 1 spec. (AMS, C.153983); Michaelmas Cay (16°36'S, 145°59'E), G.B.R. Boring expedition, 2 spec. (AMS, C.153994). NEW CALEDONIA: Lifou, 1 spec. (KBIN, Dautzenberg Collection)

Geographical distribution: Tropical western Pacific from Ambon (Indonesia), N.E. Australia, E. Papua New Guinea and New Caledonia (Fig. 3).

Variation: *Rissoina (Rissoina) vangoethemorum* sp. nov. shows some variation with respect to the relative diameter of the shell and the axial ribs on the adapical spire whorls being more or less prominent and more or less distantly spaced; otherwise, this new species appears to be rather uniform with respect to the other shell characters.

Affinities and differences: *Rissoina (Rissoina) vangoethemorum* sp. nov. is very similar in shell shape and teleoconch sculpture to *Rissoina (Rissoina) soror* sp. nov., described below, and is contrasted where the latter is introduced.

The sculpture of *R. (R.) vangoethemorum* is superficially similar to *R. (Ailinzebina)* sp. A (Sleurs, 1993), but differs in being less regular, especially on the last whorl and in the axial riblets being less closely spaced; furthermore the simple peristome and the lack of the spiral fold on the abapical third of the last whorl easily distinguishes *R. (R.) vangoethemorum* from *R. (A.)* sp. A.

R. (R.) vangoethemorum shows also some superficial resemblance to the western Atlantic *R. (Ailinzebina) elegantissima* d'Orbigny, 1842, but differs essentially in having more crowded and weaker axial ribs and in having a simple peristome.

The subcylindrical form of the protoconch and the distinctive sculpture of the teleoconch readily distinguish *Rissoina (Rissoina) vangoethemorum* from its congeners.

Etymology: This new species is named for Dr. and Mrs. Jackie and Lutgarde Van Goethem-Vanderborght and their children Bart and Ruth, who collected this species at Reamuna Islet, Papua New Guinea.

Rissoina (Rissoina) soror sp. nov.

(Figs. 1 E–G; 2 A–C; 3)

Type material: Holotype (Fig. 2 A): empty shell, Souvi Bay, S.W. coast of Viti Levu, Fiji (18°11'S, 177°36'E), coll. J. Laseron, 1962 (AMS, C.153947). Paratypes: 15 shells from type locality, coll. J. Laseron, 1962 (AMS, C.153947).

Description: Shell (Figs. 1 E, 2 A): small (length up to 4.7 mm), thin, elongately conical. Protoconch (Figs. 1 F, 2 B): of non-planktotrophic larval type; of 1 glossy whorl, strongly tilted with respect to axis of teleoconch; transition to teleoconch abrupt, with a straight, non thickened margin. Teleoconch: of about 7, low, moderately to strongly convex whorls, with deeply impressed to narrowly channeled sutures. Axial

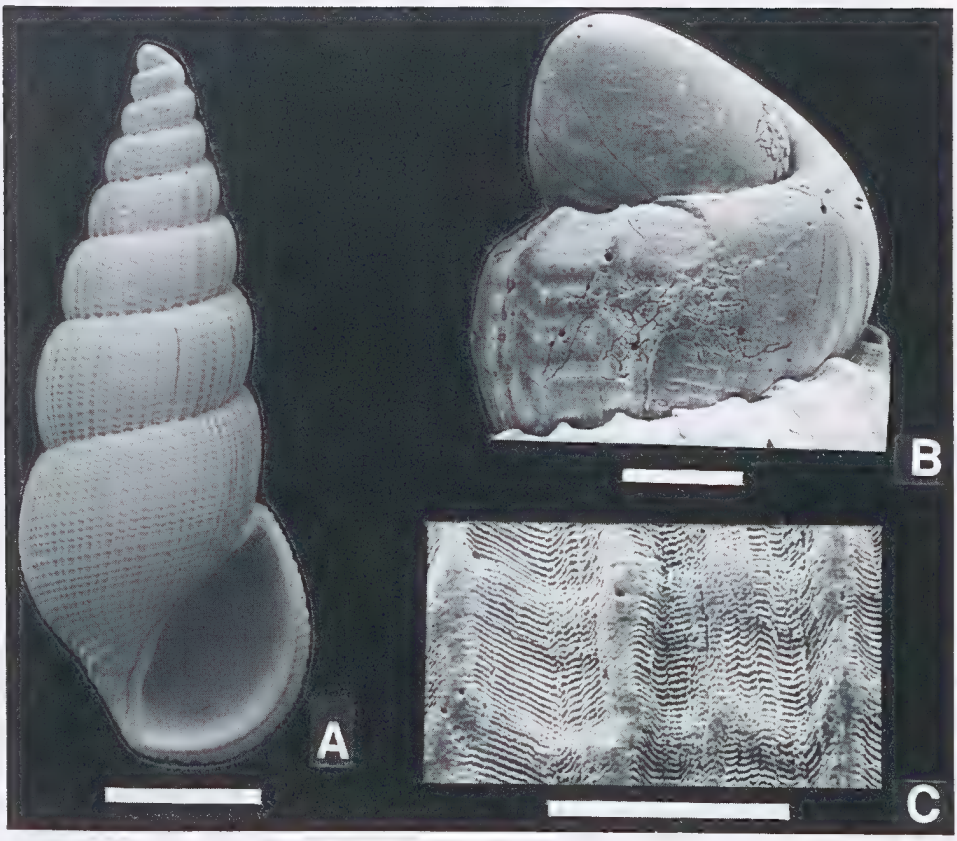

Figure 2. A–C. *Rissoina* (*Rissoina*) *soror* sp. nov. A. Holotype of *Rissoina* (*Rissoina*) *soror* sp. nov., Souvi Bay, S.W. coast of Viti Levu, Fiji, shell (scanning electron micrograph) (AMS, C.153947). B–C. Paratype of *Rissoina* (*Rissoina*) *soror*, Souvi Bay, S.W. coast of Viti Levu, Fiji (AMS, C.153947). B. Protonconch (scanning electron micrograph). **C.** Microsculpture of penultimate whorl of teleoconch (scanning electron micrograph). (Scale bars: A: 1 mm; B–C: 0.1 mm).

sculpture of prominent, narrow, distantly spaced, rounded axial ribs on adapical spire whorls, but axial ribs gradually less prominent, more numerous and more crowded on abapical spire whorls and on last whorl. Spiral sculpture of very weak, more or less distantly spaced, spiral threads, forming very weak granules where intersecting axial ribs (Figs. 1 G, 2 C); spiral threads slightly more prominent on abapical half of last whorl. Aperture: lenticular; columellar side weakly angulate centrally; anterior and posterior channel almost absent; inner lip thin; outer lip thin, weakly crenulate, with a rather prominent, narrow and rounded external varix; outer lip weakly opisthocline in profile. Colour: white throughout. Operculum, radula and internal anatomy: unknown.

Shell dimensions: See table 2.

Variation: Apart from the variable number of axial ribs on the whorls of the teleoconch, there appears to be very little variation amongst the series of specimens examined.

Table 2. *Rissoina (Rissoina) soror* sp. nov. Shell dimensions (L: total shell length; Ls: spire length; D: shell diameter; no. whorls: number of teleoconch whorls).

	L (mm)	Ls (mm)	D (mm)	no. whorls
Holotype: Viti Levu, Fiji (AMS, C.153947)				
Fig. 2 A	4.6	3.0	1.8	6 3/4
Paratypes: Viti Levu, Fiji (AMS, C.153947)				
	4.7	3.0	2.0	6 1/2
	4.3	2.7	1.8	6
	4.1	2.7	1.6	6 3/4
	4.0	2.6	1.6	6 1/2
	4.0	2.5	1.7	6
Fig. 2 B–C	3.8	2.4	1.6	6
	3.6	2.3	1.5	6
Fiji (LACM, 79–40)				
	4.3	2.8	1.7	6 1/2
Fiji (LACM, 79–42)				
	3.8	2.5	1.5	6
Tonga (AMS, C.153900)				
	3.5	2.3	1.4	6
	3.0	1.8	1.3	5
Okinawa (LACM, 77–61)				
Fig. 1 E–G	3.7	2.5	1.4	6
	3.3	2.1	1.3	5 1/2

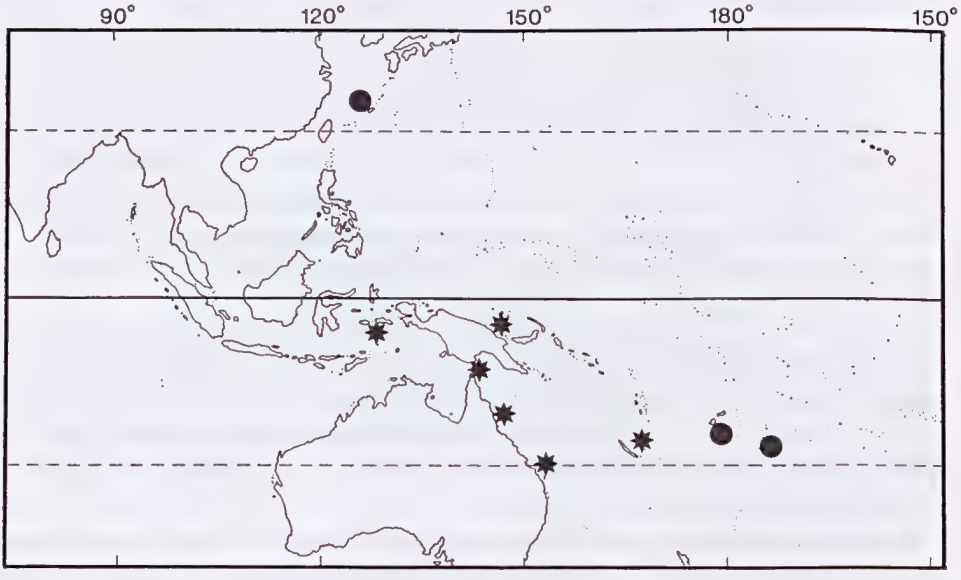

Figure 3. Geographical distribution of *Rissoina* (*Rissoina*) *soror* sp. nov. (●) and *R.* (*R.*) *vangoethemorum* sp. nov. (✳).

Additional material examined: JAPAN: Okinawa: Tengen (Kogosuku), 2–5 km NNW of Gushikawa, 5–11m, stn. 77–102 (LACM), 1 spec. (AMS, C.153857); 2.8 km S.S.W. of Kadena, 1 spec. (LACM, 77–55); 1 km N.N.W. of Oku, 7 spec. (LACM, 77–61). FIJI: ca. 1 km S. of Suva Point, Viti Levu, 1 spec. (LACM, 79–40); Korolevu, Viti Levu, 1 spec. (LACM, 79–42). TONGA: Ha'apai, beach grit, 2 spec. (AMS, C.153900).

Geographical distribution: Tropical western Pacific from Okinawa to Tonga (Fig. 3).

Affinities and differences: *Rissoina (Rissoina) soror* sp. nov. strongly resembles *Rissoina (Rissoina) vangoethemorum* sp. nov. in shell shape and sculpture, but differs essentially in having a protoconch of non-planktotrophic larval type, instead of a planktotrophic protoconch in *Rissoina (Rissoina) vangoethemorum*.

Rissoina soror superficially resembles the western Atlantic species *R. (R.) krebsii* Mörch, 1876 in teleoconch sculpture, but differs essentially in having a tilted protoconch and in the shell being less robust and more elongate.

Remarks: Despite the very disjunct distribution, no distinction can be made between specimens from Fiji, Tonga and Okinawa on the basis of shell characters only. Therefore it is not known whether the disjunct distribution is the result of poor collecting in the intervening areas, if the species was previously more widely distributed in the Western Pacific and has subsequently contracted, or if two non-planktotrophic species are represented, *i.e.* two separate speciation events took place from the planktotrophic ancestor, but without obvious subsequent evolution in teleoconch characters. The examination of additional material, with preserved soft parts, may give us a better insight in this problem.

Etymology: *Soror* (L.=sister) refers to the possibility that this species may represent a sister species of *Rissoina* (*Rissoina*) *vangoethemorum* sp. nov.

Acknowledgements

I am indebted to the following curators or persons of the institutions that have kindly made material available for this study: Dr. W. Ponder, Mr. P. Colman and Mr. I. Loch (AMS), Dr. J. Van Goethem (KBIN), Dr. J. McLean (LACM) and Dr. H. Strack (NNML). I would like to thank sincerely Dr. W. Ponder (AMS) and Dr. F. Wells, who kindly read drafts of this manuscript and offered valuable comments. I thank Mr. J. Cillis (KBIN) for assistance with scanning electron microscopy.

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Moll. Res. 15: 21–28 (1994).

Gonadal development of the hairy mussel, *Trichomya hirsuta* (Mollusca: Bivalvia) from Lake Macquarie, New South Wales

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A histological study of reproductive periodicity in the hairy mussel, *Trichomya hirsuta*, from Lake Macquarie, New South Wales, found partial spawning throughout the year in males. Few female mussels were spawning but three peaks in gonadal development and regression suggest corresponding female activity. The gonads of both sexes underwent development throughout the year.

Keywords: *Trichomya hirsuta*, Bivalvia, reproduction, New South Wales.

Introduction

Trichomya hirsuta, the hairy mussel, is common along most of the east coast of Australia excluding coral reefs and has been recorded from Tasmania, St Vincent's Gulf, South Australia and Western Australia (Klumpp and Burdon-Jones 1982). *Trichomya hirsuta* is found on rocks, muddy substrates, seagrass beds and artificial structures (Robinson and Gibbs 1982) and is an important fouling organism. It is most prevalent in marine environments forming massive, very stable populations which may carpet the substrate (Laseron 1956).

There is little information about the reproductive development of *T. hirsuta*. MacIntyre (1959) found *T. hirsuta* reproduced thoughout the year in Lake Macquarie by observing the gonad macroscopically. My work was undertaken to quantify this observation using histological techniques.

Materials and Methods

Approximately 20 *Trichomya hirsuta* were collected every 4 weeks over a 12 month period from Vales Point, Lake Macquarie, N.S.W. (33°00'S, 151°55'E) in approximately 3.5m of water and 100m offshore. This is the site of a huge population of *T. hirsuta* which occurs as clumps of 100 to 200 mussels on the soft mud substrate. Mussels over 30mm length were selected randomly from several clumps. The sex of the mussels was not determined at this stage.

A hole was bored in the shells and the mussels fixed in either Bouins solution or 20% formal-saline. The mussels were removed from their shells and stored in 70% alcohol. A transverse piece of tissue was taken between the byssal retractor and posterior adductor muscles, dehydrated in graded alcohols, cleared in methyl-benzoate and embedded in 'Paraplast Plus' histological wax. Sections were cut at 8µm, stained with Mayer Haematoxylin and eosin-Y (Humason 1962) and mounted in D.P.X.

Individual slides were assigned to a reproductive stage, modified from Wilson and Hodgkin (1967), which is defined below. A range of reproductive stages was found in

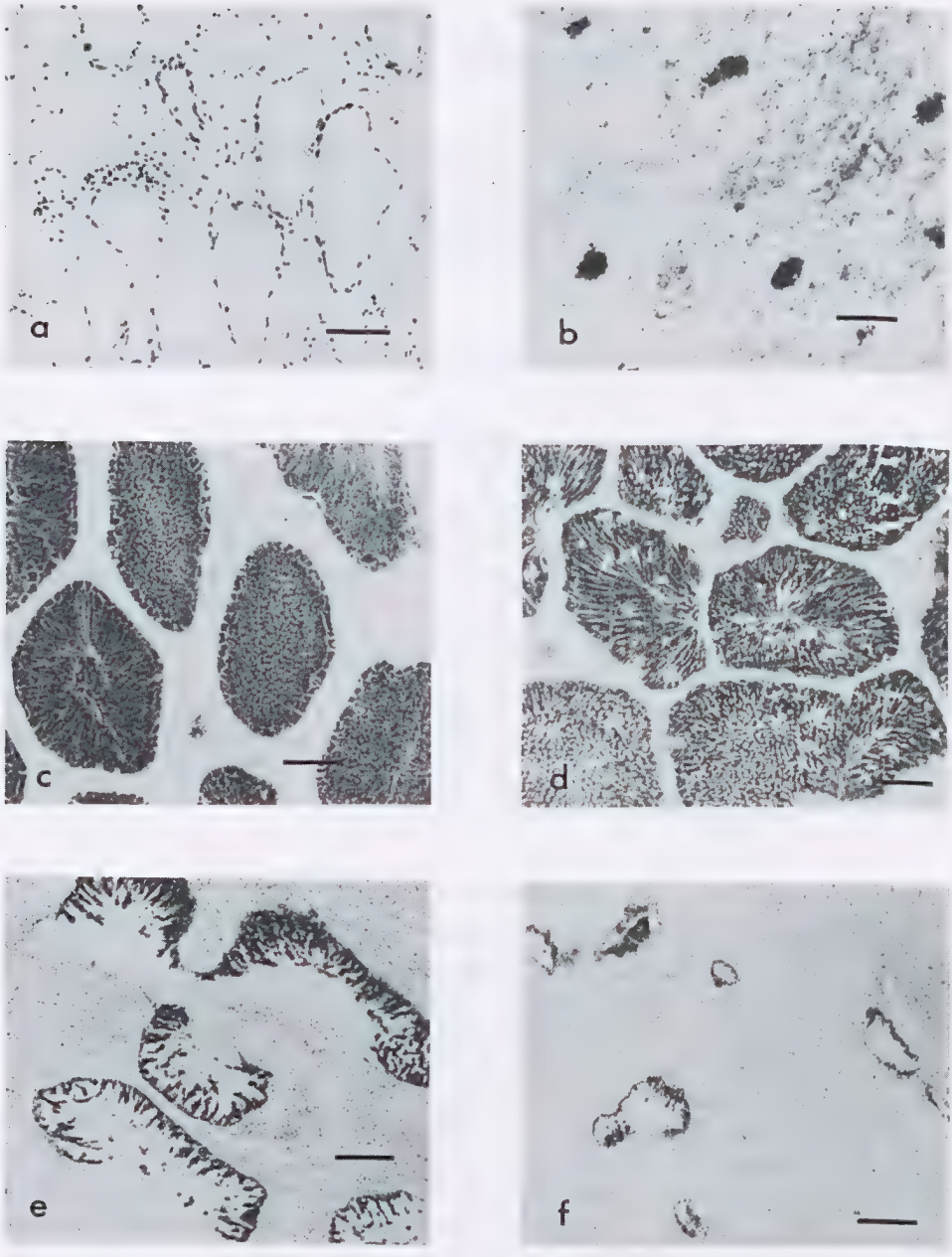

Figure 1. Male reproductive stages in *Trichomya hirsuta*. (a) resting: stage R; (b) early development: stage d1; (c) secondary development: stage d2; (d) sexually ripe: stage d3; (e) spawning: stage r1; (f) secondary: stage r2. (scale bar = 0.1mm).

individual mussels, particularly in males. For each mussel, the proportion of the gonad in each reproductive stage was estimated by scanning the entire histological section. These proportions were totalled for each stage at each sampling period and plotted.

The sex-ratio of the total sample was calculated and a chi-square test was performed to determine if it was significantly different from 1:1.

Gonad Classificatory Stages (Fig. 1 and 2).

RESTING OR INDETERMINATE (STAGE R): The sex of the mussel is difficult or impossible to determine at this stage (Fig. 1a).

EARLY DEVELOPMENT (STAGE d1): Gametogenesis begins: the tubules are small and filled with early gametogenic stages (Figs 1b and 2a).

SECONDARY DEVELOPMENT (STAGE d2): The tubules enlarge. In the male, early gametogenic stages; spermatogonia, spermatocysts and spermatids, form a wide band at the edges of the tubules (Fig. 1c). These are eosinophilic in contrast to the inner region of basophilic spermatozoa. In the female, the oogonia and early oocytes are attached to the tubule wall (Fig. 2b).

RIPE (STAGE d3): The gonads ramify throughout most tissues and little connective tissue is visible between the tubules. In the male, there is a thin, peripheral band of young gametogenic cells with ripe spermatozoa in the centre of the tubule. In the female, most oocytes detach from the wall and become polygonal due to pressure in the tubules (Figs 1d and 2c).

SPAWNING (STAGE r1): Tubules remain enlarged but spermatozoa and oocytes have been shed from the centre of the lumen and remaining oocytes become more circular with the decreased density. Breakdown of the remaining oocytes or spermatozoa begins (Figs 1e and 2d).

REGRESSION (STAGE r2): The size of the tubules has diminished and few spermatozoa and oocytes remain. A secondary development of germ cells on the tubule walls may commence (Figs 1f and 2e).

Results

Mussels of indeterminate sex (stage R) were most frequent in May. The ratio of sampled males:females:indeterminate mussels was 0.53:0.43:0.03. Ratio of males to females was not significantly different to 1:1 ($0.25<p<0.10$).

Males

No single well-defined spawning season was found for 146 male *Trichomya hirsuta* from Lake Macquarie (Fig. 3). Males in early gonadal development stage (d1) were few and found in March and May. There were three peaks of male mussels in the secondary development stage (d2), in June through August, December to February, and May: these peaks progress to stage d3 in July through September, December through February and May respectively and finally to spawning (stage r1) in December, April and June respectively. Regression (r2) coincided with spawning, with peaks in November, April and July.

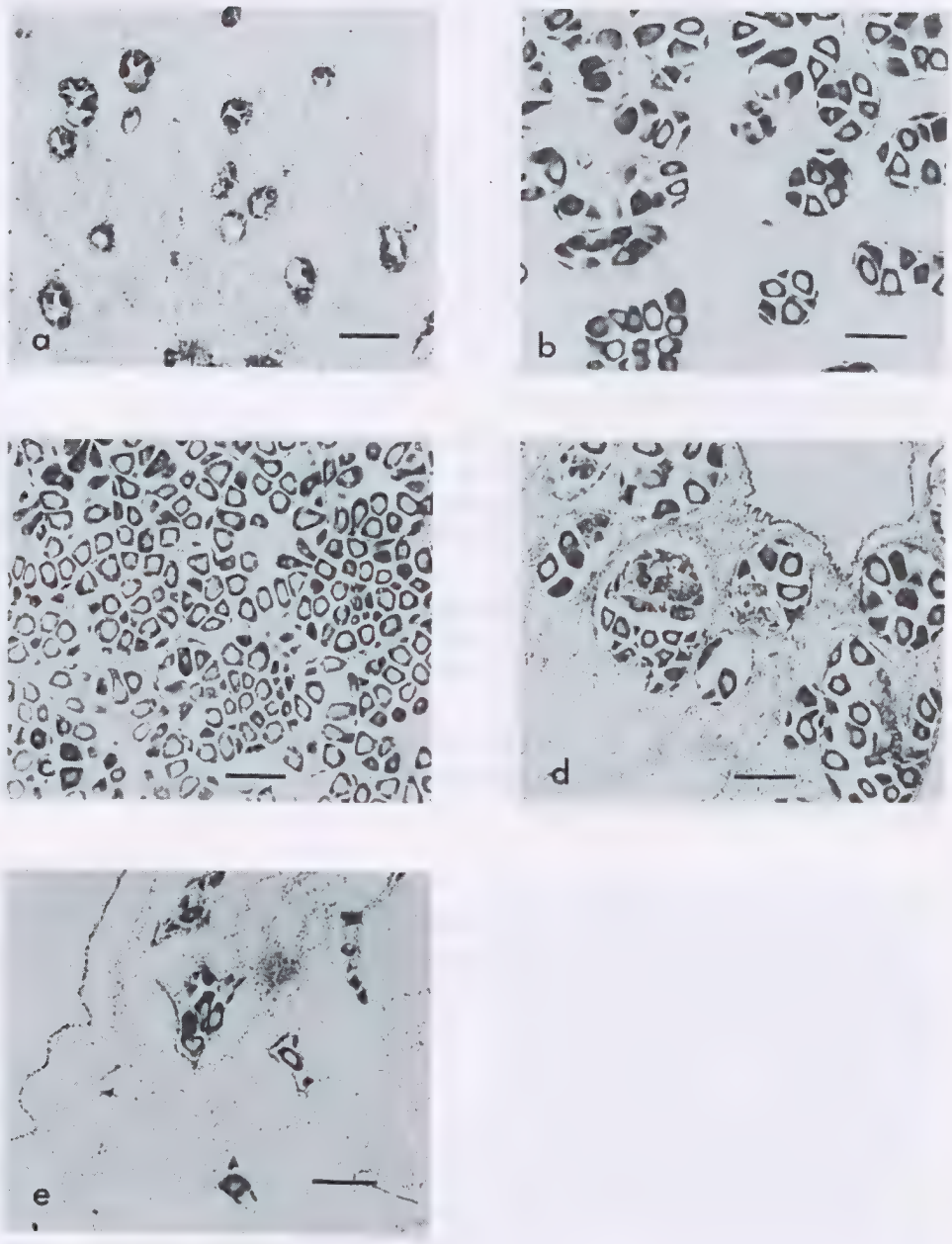

Figure 2. Female reproductive stages in *Trichomya hirsuta*. (a) early development: stage d1; (b) secondary development: stage d2; (c) sexually ripe: stage d3; (d) spawning: stage r1; (e) secondary regression: stage r2. (scale bar = 0.1mm).

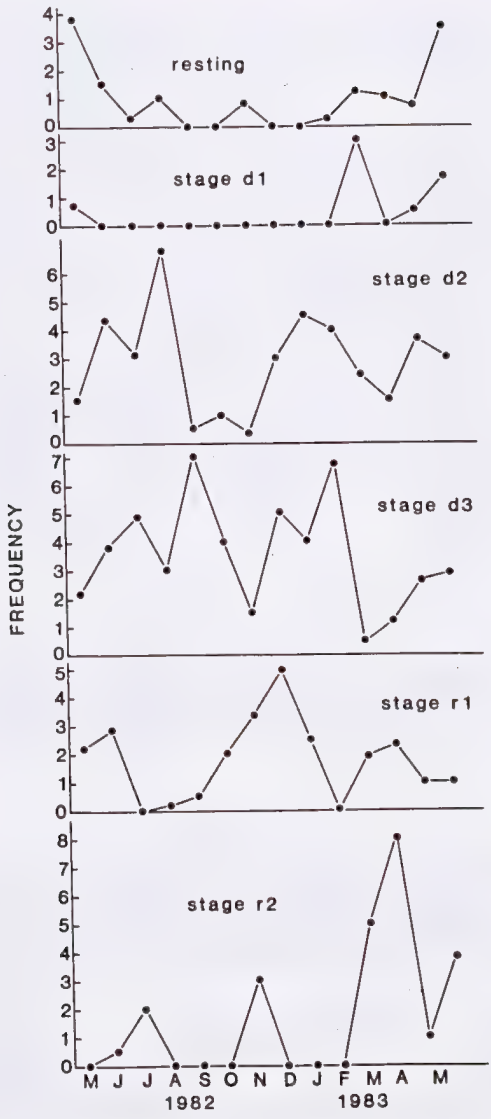

Figure 3. Seasonal incidence of reproductive stages in male *Trichomya hirsuta* (see text for derivation of frequency).

Females

No single well-defined spawning season was found for 119 *T. hirsuta* females (Fig. 4). More females than males were found in early development stage (d1) with 3 peaks in July/August, November and April/May. Females in the secondary development (d2) stage were most abundant in August through October, December to February, and May. Many females were ripe (stage d3) most of the year, particularly from September until February and in May. Spawning females were found in July, October and May. Most regressed females (r2) were found in January and March/April.

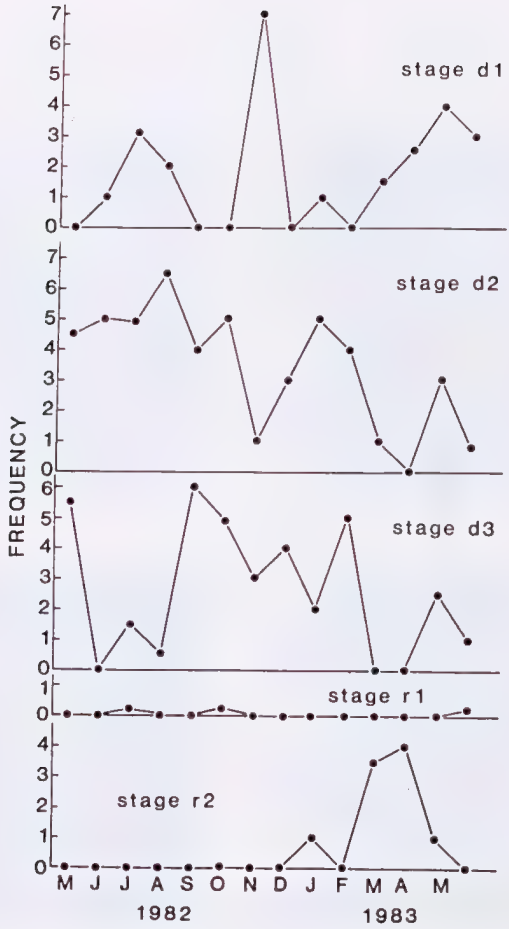

Figure 4. Seasonal incidence of reproductive stages in female *Trichomya hirsuta* (see text for derivation of frequency).

Discussion

Year-round spawning was found in male *Trichomya hirsuta* with 3 peaks in reproductive activity apparent in all stages of development. Spawning peaks were apparent for males in early winter, early summer and early autumn. Spawning of females is indicated coincident with males, by extrapolating from peaks of gonadal development. Few spawning females were found perhaps because the shedding of eggs is very brief, while redevelopment is continuous and coincides with spawning in any one tubule. Furthermore, spawning may occur in a small percentage of tubules of an individual female and be overlooked. It is probable an increased sample size would improve the resolution of the spawning period in female *T. hirsuta*.

These histological analyses support macroscopic observations by MacIntyre (1959) who found *T. hirsuta* spawning throughout the year in Lake Macquarie. Continuous spawning in *T. hirsuta* from Lake Macquarie is further supported by length-frequency data from this population. Small mussels were found throughout the year and length-

frequency data could not be resolved into modes concordant with a single specific spawning period (unpublished data). Spawning throughout the year is not uncommon in mussels and has been recorded from *Mytilus viridus* (Tan 1975) in Singapore, *Modiolus modiolus* (Seed and Brown 1975) in Northern Ireland and *Mytilus edulis* in Wellington, New Zealand (Ralph and Hurley 1952).

Wilson and Hodgkin (1967) found that temperature was a significant factor in determining reproductive activity in Australian mussels. The length of the reproductive season in southern mussels is extended in populations found further south (Baird 1976). For example, *Mytilus edulis planulatus* spawns predominantly in winter in Sydney Harbour (Allen 1955; Wisely 1964) while the reproductive season is extended in Tasmania and spawning occurs in late winter, early spring, summer and autumn (Dix and Ferguson 1984). Similarly, *Trichomya hirsuta* from Lake Macquarie have an extended period of reproductive activity. It is possible that reproductive activity of *T. hirsuta* may be restricted in populations found further north.

Year-round partial spawning and redevelopment are indicated for *T. hirsuta* from Lake Macquarie which is a successful reproductive strategy to maintain the massive populations found at this location.

Acknowledgements

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Development and histological characteristics of neurosecretory cells in the cerebral ganglia of *Achatina fulica* (Bowdich)

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Study of postembryonic development of neurosecretory cells in the cerebral ganglia of *Achatina fulica* showed that they first appear in two-month-old snails. The cells are located at the periphery of the procerebrum of cerebral ganglion. The number and size of the neurosecretory cells increase with increasing age of snails, reaching a maximum in eight-month-old snails and thereafter remaining constant in nine- to twelve-month-old snails.

Study of the ultrastructure of the cells showed that they each contain a round shaped nucleus with patches of heterochromatin and a conspicuous single large vacuole in the cytoplasm. In addition, electron-dense elementary granules with a mean diameter of 1600 A° are found to be associated with an extensive Golgi complex and rough endoplasmic reticulum.

Key words: cerebral ganglia, *Achatina*, neurosecretory cells

Introduction

The occurrence of neurosecretory cells in pulmonate snails was first reported by Gabe (1954). Various types of neurosecretory cells can be distinguished on the basis of stainability of neurosecretory cells to different histochemical methods, such as chrome-hematoxylin phloxine (Gomori, 1941) and paraldehyde-fuchsin (Gomori, 1950). The presence of neurosecretory cells in various ganglia of pulmonate snails had been extensively studied. In the basommatophoran, *Lymnaea stagnalis* (L.), the neurosecretory cells are found in the cerebral, pleural, parietal and visceral ganglia (Boer, 1965; Boer and Joosse, 1975). In other basommatophorans, *Australorbis glabratus* (Say) and *Helisoma tenue* (Philippi), neurosecretory cells are present in the cerebral, parietal and visceral ganglia (Lever *et al.*, 1965; Simpson *et al.*, 1966). In stylommatophoran snails, the neurosecretory cells were reported to be present in the cerebral, buccal, parietal and pleural ganglia as well as in the optic tentacles of *Arion ater* (L.) (Smith, 1967), in the buccal ganglia of *Succinea putris* (L.) (Cook, 1966), in the cerebral ganglia (Kai-Kai & Kerkut, 1979) and optic tentacles of *Helix aspersa* (Müller) (Lane, 1964), and in the optic tentacles of *Archachatina marginata* (Swainson) (Nisbet, 1965), *Arion subfucus* (Draparnaud) and *Limax maximus* (L.) (Pelluet & Lane, 1961) and *Milax* spp. (Draparnaud) (Pelluet, 1964). However, there is no report on the presence of neurosecretory cells in the pedal ganglia of pulmonate snails.

The ultrastructure of neurosecretory cells in the cerebral ganglia was studied in *L. stagnalis* (Boer *et al.*, 1968). There are numerous organelles distributed in the cell cytoplasm *i.e.*, mitochondria, rough endoplasmic reticulum, free ribosomes, polysomes, Golgi apparatus, multivesicular bodies and microtubules. In addition, there are electron-dense elementary granules with a mean diameter of 2000 A° in the cytoplasm.

Most of the knowledge on molluscan neurosecretory cells has been obtained from studies of basommatophoran snails and some stylommatophoran snails (Boer & Joosse, 1975). However, there is virtually no data on the neurosecretory cells of a stylommatophoran, *Achatina fulica* (Bowdich). Hence, the aim of the present study is to report on the development and histological characteristics of neurosecretory cells in the cerebral ganglia of *A. fulica*.

Materials and methods

The process of breeding culture and environmental conditions, the culturing of parent and young snails and the measurement of growth were carried out by the methods of Upatham *et al.* (1988).

Mature *A. fulica* with a shell length of 7 cm (5–7 months of age) were used for morphological study of the neurosecretory cells. The postembryonic development of the neurosecretory cells in the cerebral ganglia was studied in 10 snails out of snails at monthly age of 0–12. In addition, two-week-old snails were examined.

All snails were anesthesized with 1% nembutal for 1 hour, then their shells were broken, cerebral ganglia dissected out and fixed immediately in Bouin's fluid for 12 hours. The specimens were then dehydrated through a graded series of ethanol, infiltrated with dioxane, and embedded in paraffin. Sections were cut on a rotary microtome at 6 μm thickness, stained with chrome-hematoxylin phloxine (Gomori, 1941) and paraldehyde-fuchsin (Gomori, 1950) and examined in an Olympus Vanox light microscope. In addition, the size and number of neurosecretory cells in the cerebral ganglia were measured and counted.

Cerebral ganglia from mature snails were fixed in 2.5% glutaraldehyde in 0.1 M sodium cacodylate buffer, pH 7.4 at 4°C for 2 hours, washed three times in the same buffer and postfixed in 1% OsO_4 in 0.1 M sodium cacodylate buffer, pH 7.4 for 2 hours. The specimens were washed three times with cold distilled water, stained *en bloc* with 1% uranyl acetate in 0.1 M sodium acetate buffer pH 5.1 at room temperature for 1/2 hour, dehydrated through a graded series of ethanol, and embedded in Araldite 502 epoxy resin. Sections were cut with glass knives on a Sorvall MT 2 ultramicrotome, stained with uranyl acetate and lead citrate, and viewed with a Hitachi H–300 TEM, operating at 75 KV.

Results

Neurosecretory cells in the cerebral ganglia which stain positive with chrome-hematoxylin phloxine and paraldehyde-fuchsin occur in the procerebrum of the cerebral ganglia in snails of various ages. These cells stain blue-black with chrome-hematoxylin phloxine and deep purple with paraldehyde-fuchsin. There are no neurosecretory cells in the cerebral ganglia of newly hatched and one-month-old snails (Fig. 1A). Neurosecretory cells with a mean diameter of 17.1 μm (Fig. 3A) first appear in the

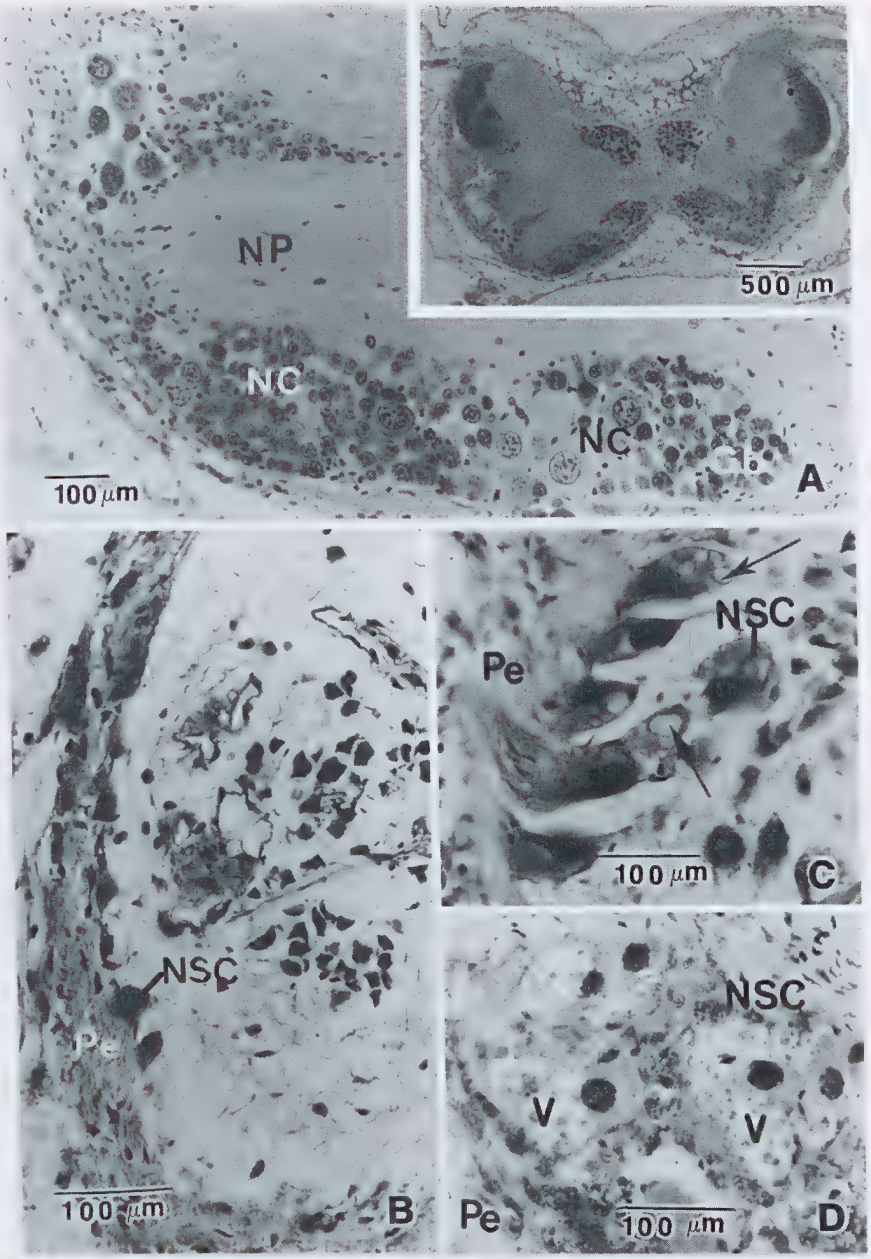

Figure 1. Photomicrographs of longitudinal sections through cerebral ganglia stained with chrome-hematoxylin phloxine. A. High magnification of cerebral ganglion in newly hatched snail showing groups of nerve cells (NC), globuli cells (Gb) and neuropil (NP) of procerebrum. Inset shows overall view of cerebral ganglia in newly hatched snail. B. Cerebral ganglion of two-month-old snail showing neurosecretory cells (NSC) at perineurium (Pe). C. Large neurosecretory cells (NSC) with numerous small vacuoles (arrows) lying against perineurium (Pe) in five-month-old snail. D. Neurosecretory cells (NSC) in nine-month-old snail which contain a conspicuous single large vacuole (V). Pe = perineurium.

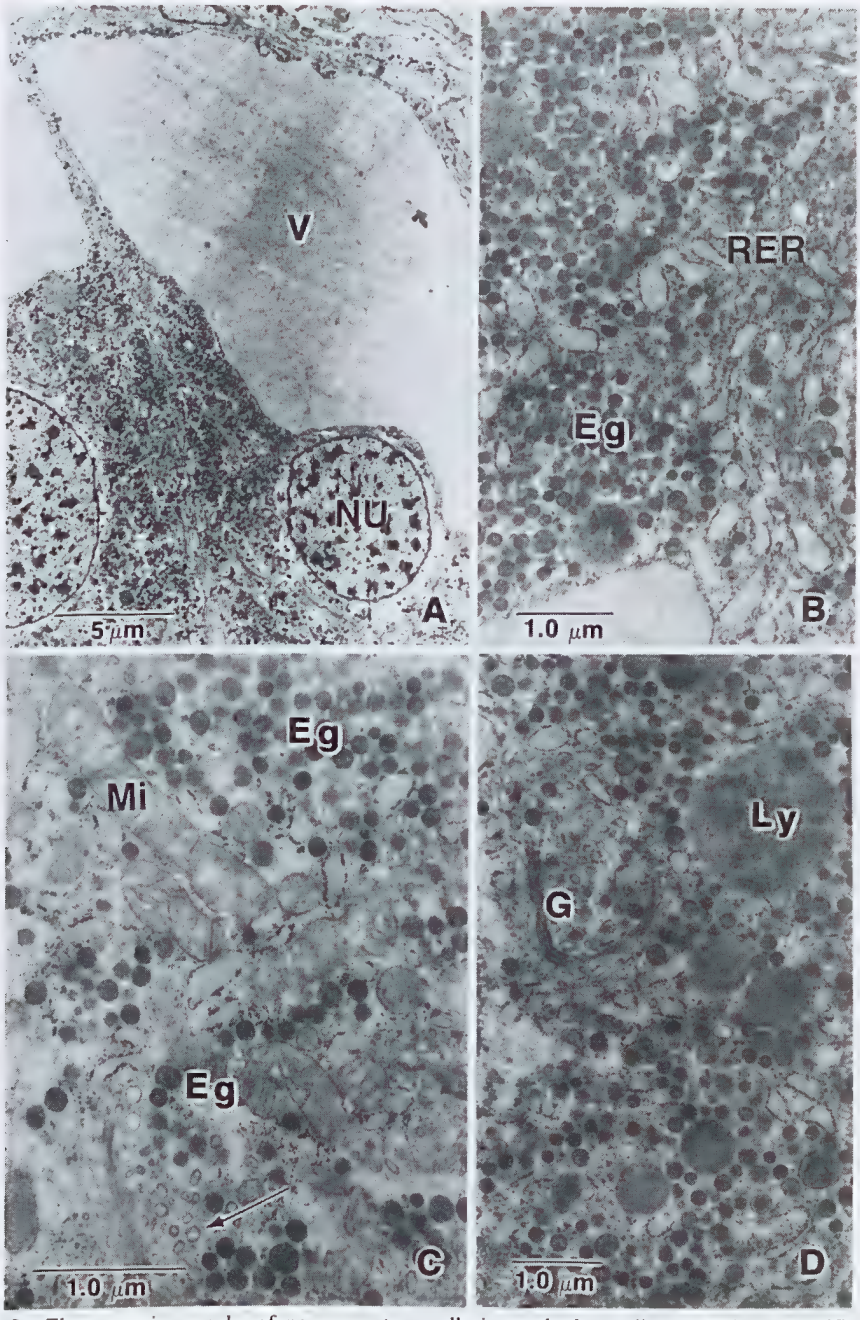

Figure 2. Electron micrographs of neurosecretory cells in cerebral ganglia A. At low magnification, showing neurosecretory cell with heterochromatic nucleus (NU) and single large vacuole (V). B. Cytoplasm of neurosecretory cell, showing very extensive rough endoplasmic reticulum (RER) and numerous electron-dense elementary granules (Eg). C. Cytoplasm of neuroscretory cell, showing numerous mitochondria (Mi). Electron-dense elementary granules (Eg) are associated with microtubules (arrows). D. Showing many groups of Golgi body (G) and lysosomes (Ly) in cytoplasm.

cerebral ganglia of two-month-old snails. There are nine cells (Fig. 3B) which are located in a single layer at the periphery of the procerebrum (Fig. 1B).

In three-month-old snails, the mean diameter of neurosecretory cells increases slightly (19.8 μm) while the number increases up to 59.5 cells per ganglion (Fig. 3). In four-month-old snails, the neurosecretory cells occur in two or three layers and the mean diameter and number of neurosecretory cells increase to 21 μm (Fig. 3A) and 99 cells per ganglion (Fig. 3B), respectively.

In five-month-old snails, the neurosecretory cells contain numerous small vacuoles (Fig. 1C) and they differ in size within a cluster, with the largest cells located in the most peripheral layer. The mean diameter of neurosecretory cells in five-month-old snails is 21 μm (Fig. 3A). The number of neurosecretory cells increases to 107 cells per ganglion (Fig. 3B).

The mean diameter of neurosecretory cells continues to increase slightly in six to twelve-month-old snails (Fig. 3A). The number of neurosecretory cells continues to increase in six- to eight-month-old snails. It reaches to a peak in eight-month-old snails. The number then decreases in nine-month-old snails but remains constant in nine- to twelve-month-old snails (Fig. 3B).

In some neurosecretory cells of six to eight-month-old snails, the small vacuoles have fused to form a single large vacuole which appears to accumulate some substance which stains pink or red with phloxine. Other cells, however, still contain several small vacuoles. In nine to twelve-month-old snails, all the neurosecretory cells in the cerebral ganglia contain a round nucleus and a single large vacuole (Fig. 1D).

The transmission electron microscope reveals that the neurosecretory cells are closely attached to the perineurium or surrounding connective tissue of the cerebral ganglion. The nucleus of neurosecretory cells is round and heterochromatic (Fig. 2A). There is a conspicuous single large vacuole in the cell (Fig. 2A). In the cytoplasm, the cisternae of rough endoplasmic reticulum are highly elaborate and arranged in many arrays (Fig. 2B). The electron-dense elementary granules with a mean diameter of 1600 A° are the prominent inclusions found in the cytoplasm (Fig. 2B). These granules are intermingled with microtubules and numerous mitochondria (Fig. 2C). Moreover, there are many groups of Golgi apparatus, each consists of many saccules (Fig. 2D). Lysosomes are also numerous in the cytoplasm of these neurosecretory cells (Fig. 2D).

Discussion

The occurrence of neurosecretory cells has been investigated in many species of pulmonate snails, *i.e.*, *L. stagnalis* (Joosse, 1964; Boer, 1965), *A. glabratus* (Lever *et al.*, 1965), *H. tenue* (Simpson *et al.*, 1966), *H. duryi* (Wetherby) (Dillaman *et al.*, 1976) and *A. ater* (Smith, 1967), usually with chrome-hematoxylin phloxine and paraldehyde-fuchsin staining methods (Gomori, 1941; 1950). In the present study, these two methods were chosen to study the development of neurosecretory cells in the cerebral ganglia of *A. fulica*.

Postembryonic development of neurosecretory cells in the cerebral ganglia showed that they first appear in two-month-old snails. A large number of neurosecretory cells is found in eight-month-old snails which apparently is correlated with the growth of the snails. These neurosecretory cells occurred in constant and specific areas.

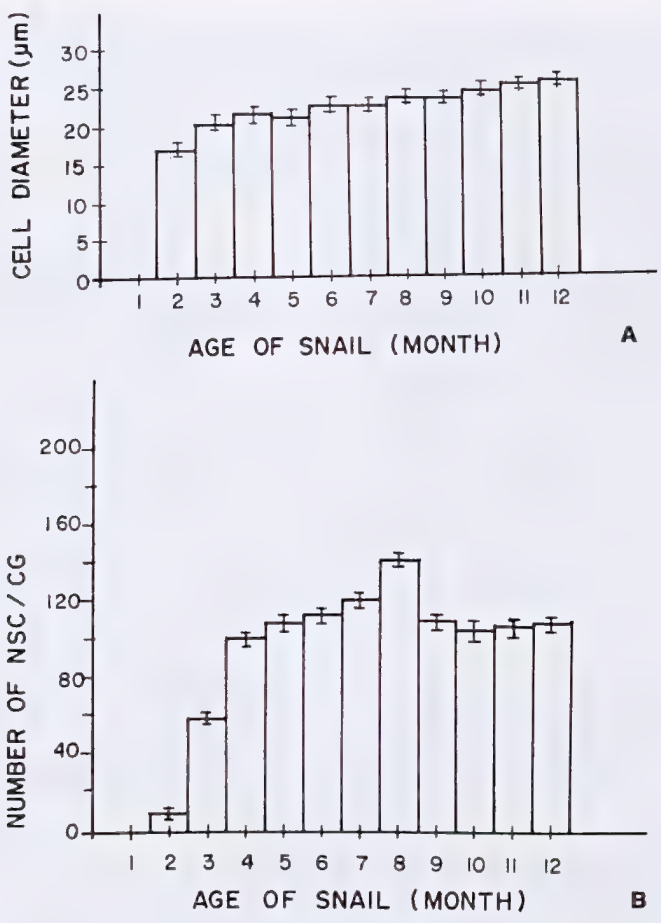

Figure 3. A. The mean diameter of neurosecretory cells in cerebral ganglia of *Achatina fulica* at various ages. B. The number of neurosecretory cells (NSC) in cerebral ganglia (CG) of *Achatina fulica* at various ages.

There are many reports on the functions of neurosecretory cells in the cerebral ganglia of basommatophoran and stylommatophoran snails. The light green cells in the cerebral ganglia of *L. stagnalis*, and the medial cells in the cerebral ganglia of *Agriolimax reticulatus* (Müller) have a factor that stimulates growth rate (Geraerts & Algera, 1976; Widjenes & Runham, 1977). The caudo-dorsal cells, found only in *L. stagnalis*, affect ovulation and egg-laying behavior (Geraerts & Bohlken, 1976). However, in stylommatophoran snails, there is a substance that stimulates the movement of oocytes. Saleuddin *et al.* (1983) reported that the brain extract (cerebral ganglia with their capsule) caused the amoeboid movement of oocytes in *H. aspersa*.

The development of neurosecretory cells in the cerebral ganglia of *A. fulica* involves two processes, increases in cell size and cell number. The development of these neurosecretory cells may be correlated to the development of the reproductive organs. Ngowsiri *et al.* (1988) reported that the oocytes first appear in the ovotestis of *A. fulica*

at the age of about five months. At this stage, there are many large neurosecretory cells in the cerebral ganglia. The snails reach sexual maturity in five to seven months (Bequaert, 1950; Pawson & Chase, 1984; Upatham *et al.*, 1988; Mohr & Meer, 1949; Kondo, 1964).

Ngowsiri *et al.* (1988) reported that in *A. fulica*, the number of oocytes progressively increased as the snails approached the age of 7–8 months, and in the present study, the number of neurosecretory cells is shown to increase at a similar rate. It thus may be suggested that the neurosecretory cells in the cerebral ganglia of *A. fulica* have a direct effect on the production of oocytes in the ovotestis.

The ultrastructure of the neurosecretory cells is indicative of high synthetic activity. There are electron-dense elementary granules which occur in association with well developed rough endoplasmic reticulum and Golgi apparatus. In the active medio-dorsal cells and latero-dorsal cells of the cerebral ganglia of *L. stagnalis*, the Golgi complex is extremely large (Boer, 1965). The Golgi lamellae contain electron-dense elementary material which is formed into electron-dense elementary granules by budding (Boer, 1965). A similar event also occurs in the neurosecretory cells in the cerebral ganglia of *A. fulica*.

The cytoplasm of neurosecretory cells in the cerebral ganglia of *A. fulica* contains abundant electron-dense elementary granules, with a mean diameter of 1,600 A°. Electron-dense elementary granules (1,000–3,000 A°) containing neurohormones have been described in "Gomori-positive" cells in various species of snails (Boer *et al.*, 1965; Lever *et al.*, 1965; Simpson *et al.*, 1966; Wendelaar Bonga, 1970).

The presence of a large vacuole in the cell is another characteristic of the neurosecretory cells in the cerebral ganglia of *A. fulica*. These vacuoles, as observed with the light microscope, usually contain pink or red substance when stained with chrome-hematoxylin phloxine. No vacuole is present in ordinary neurons. These vacuoles might be intracellular storage of neurohormones similar to the lumen of thyroid cells in vertebrates (Nadler *et al.*, 1962).

The transport of neurosecretory material *in vivo* has not been critically studied but a few workers suggested that microtubules might be involved (Loh *et al.*, 1975; Roubos, 1975). In *A. fulica*, there are numerous microtubules dispersed in the area of electron-dense elementary granules, which may function in the transport of neurosecretory material. In *H. aspersa*, the localization of electron-dense elementary granules along the periphery of neurosecretory cells adjacent to the connective tissue and the presence of dense clusters of granules in the connective tissue indicates the release of neurosecretory material (Kai-Kai & Kerkut, 1979). Wendelaar Bonga (1970) reported the peripheral release of neurosecretory products in *L. stagnalis*. In *A. fulica*, the neurosecretory cells are closely attached to the perineurium or connective tissue of the cerebral ganglia. Hence, it may be suggested that the neural sheath of the cerebral ganglia might be the neurohaemal area of neurosecretory cells.

Acknowledgements

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Levels of noradrenaline and adrenaline in the cerebral ganglia of the land snail *Achatina fulica* Bowdich in respect to aestivation.

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Key words: *Achatina*, land snail, cerebral ganglia, noradrenaline, adrenaline.

The role of monoamines occurring in nerve ganglia of molluscs is still speculative (Hill and Welsh, 1966; Osborne, 1984; Coon and Bonar, 1986; Croll, 1987a; 1987b; 1988; Panigrahi *et al.*, 1992; 1994). Since certain molluscs, especially terrestrial ones, are adapted to overcome a long period of environmental hazards by undergoing either aestivation or hibernation it is of interest to know whether such phenomena are influenced by the monoamines or if the rate of synthesis or release of monoamines is influenced by these phenomena. Accordingly the aestivation of giant African land snails, *Achatina fulica* Bowdich, occurring in Calcutta was studied.

Achatina fulica in Calcutta aestivate with the onset of dry weather, usually during the first half of November. Depending on weather conditions the snails spend six to eight months in aestivation (Raut, 1991a). For the present study a total of 200 individuals between 50 and 55 mm in shell length and 42.61 and 44.53 g in body weight were collected from the garden of the Institute of Jute Technology, Ballygunge, Calcutta in October 1988. They were released into four terraria (each 75 x 50 x 20 cm in size) in equal numbers and reared following the technique described by Raut (1991b). Keeping parity with the natural time of aestivation the snails of two terraria were deprived of food and moisture (by discontinuing water spraying on the soil of the terrarium) from November 12, 1988. Most of the snails aestivated during the next three days. By this time at least 75% of the snails in the garden of the Institute of Jute Technology aestivated at the same time. On the first day of aestivation (November 15, 1986) four active individuals (two from each of the terraria where the snails were kept active) and four individuals from the drying terraria were separated for study. These individuals were weighed and anaesthetized with chloroform. The cerebral ganglia of these snails were quickly dissected out and processed for spectrophotofluometric determination of noradrenaline and adrenaline following Cox and Perhach (1973) and Laverty and Taylor (1968). The estimation of monoamines present was made with a Hitachi Model 650–10M fluorescence spectrophotometer as described by Mahata and Ghosh (1989). Similar sampling of cerebral ganglia was undertaken monthly. Since aestivated snails failed to survive beyond April 12, 1989 the final sampling was conducted on March 15, 1989. In all cases three readings were taken to calculate the mean amount of monoamines (noradrenaline and adrenaline) in the cerebral ganglia.

Noradrenaline and adrenaline levels in aestivated and active (control) *A. fulica* are presented in Table 1 and statistically analyzed in Table 2. Variations in noradrenaline and adrenaline levels in the cerebral ganglia of *A. fulica* are clear. While the fall in the levels of these amines in the first 30 days of aestivation can be attributed to the effects

Table 1. Levels of monoamines in μg/g tissue (±S.D.) in *Achatina fulica*.

Sampling Dates	Active (Control)		Aestivated	
	Noradrenaline	Adrenaline	Noradrenaline	Adrenaline
November 15, 1988	14.39 (1.64)	12.62 (1.22)	14.39 (1.64)	12.62 (1.22)
December 15, 1988	12.70 (1.09)	17.17 (1.23)	3.58 (0.45)	7.26 (1.22)
January 15, 1989	15.93 (1.04)	18.47 (1.19)	37.87 (1.47)	40.97 (1.81)
February 15, 1989	24.17 (1.33)	21.43 (1.26)	43.85 (1.00)	64.24 (1.52)
March 15, 1989	27.53 (1.48)	26.16 (0.91)	42.77 (1.28)	67.24 (1.43)

of the onset of aestivation, the subsequent gradual increase in these amines is perhaps dependent on the physiological adjustment of the snails to the interacting effects of the length of aestivation and climatic factors. Since the snails used are adapted to undergo aestivation with the onset of adverse climatic conditions they were not able to overcome this even if kept active under favourable conditions during the natural aestivation period. As a result noradrenaline and adrenaline were synthesized at an increasing rate over time corresponding to the normal aestivation period.

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Table 2. Results of Analysis of Variance (ANOVA) and student's 't' test (indicated by P-values).

Source of variation	d.f.	SS	MS	F.cal	Ftab (P=0.05)	Remarks
Month (A)	4	9485.618	2371.404	926.026	2.61	S
Expt. (B)	1	3106.809	3106.809	1213.199	4.08	S
Noradrenaline/ Adrenaline (C)	1	394.7031	394.7031	154.1303	4.08	S
A x B	4	3953.274	988.3184	385.9353	2.61	S
A x C	4	320.711	80.17774	31.30916	2.61	S
B x C	1	360.9766	360.9766	140.9602	4.08	S
A x B x C	4	542.543	135.6357	52.96532	2.61	S
Error	40	102.4336	2.56084	–	–	–
Total	59	18267.07	–	–	–	–

S = Significant.

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Notes on the Australian species of *Calliotropis* (Gastropoda: Trochidae) with descriptions of four new species

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This paper reviews the Australian species of the genus *Calliotropis* Seguenza, 1903. *Calliotropis glypta* Watson, 1886 was the only species known to occur in Australia. Four new species are described: *Calliotropis echidna*, *C. carinata*, *C. canaliculata* and *C. lamellifera* from off the New South Wales and Queensland coasts. *Calliotropis acherontis* Marshall, 1979 is recorded from off the eastern Australian coast.

Key words: Gastropoda, Trochidae, *Calliotropis*, new species

Introduction

The genus *Calliotropis* Seguenza, 1903 is found worldwide, mainly offshore at bathyal (< 200 m) to abyssal depths on fine bottoms (Hickman and McLean, 1990). Currently, there are about sixty described species in this genus, but least 25 undescribed species are known (C. Hickman, personal communication). The type species is a fossil from the Italian Pliocene.

Calliotropis is a member of the tribe Calliotropini Hickman and McLean, 1990, which can be diagnosed by a laterally expanded tip of the snout and a radula with only three lateral teeth per half row; the rachidian tooth is reduced in size relative to the lateral teeth (Hickman and McLean, 1990). The tribe also contains genera such as *Bathybembix* Crosse, 1892 and *Lischkeia* Fischer, 1880.

The shells are thin and variable in shape and size. They may be umbilicate or imperforate. The outer lip is simple, not thickened, without teeth or lirae. Shells have an exquisite sculpture, with spiral rows of spines or peaks. Very few have any pigmentation; most are white. The shell surface is lustreless, overlaid with a dull calcareous layer of white material characteristic of many species that live in deep water. The inside is nacreous and this often shines through the outer layer. The presence of an obvious periostracum has not been observed in Australian species.

So far, *C. glypta* (Watson, 1886) is the only species of *Calliotropis* recorded from off the Australian coast. This species has a large, widely umbilicate shell, and is relatively common. When first discovered, this shell looked so unlike any other species of Australian Trochidae, that the generic placement seemed a problem. Iredale created a new genus *Mazastele* for this species (Iredale, 1936), which was originally placed in the Calliostomatinae, although Iredale and McMichael (1962) indicate the placement of this genus as 'uncertain'. Recently Marshall (1979) recognised it as a species of *Calliotropis*.

Sampling off the eastern Australian coast, mainly by the HMAS 'Kimbla' and FRV 'Kapala', has yielded a number of new small-shelled species of *Calliotropis*, which are

described in this paper, as well as a species known previously from New Zealand. *C. glypta* is described and figured for comparison.

Materials and methods

All material referred to is located in the Australian Museum, Sydney (AMS). Type specimens from the Schepman collection in the Zoological Museum of the University of Amsterdam (ZMA) have been studied. Measurements of shell height (h), width (w) and height of the aperture (a) were taken from undamaged adult shells only. The measurements of the holotype are given separately; the largest and smallest of the paratype(s) are given. The number of specimens in each lot is indicated in brackets. Additional abbreviation: NMNZ, National Museum of New Zealand.

Taxonomy

Family Trochidae Rafinesque, 1815

Subfamily Eucyclinae Koken, 1897

Tribe Calliotropini Hickman and McLean, 1990

Genus *Calliotropis* Seguenza, 1903

Type species *C. ottoi* Philippi, 1844. Italian, Pliocene.

Calliotropis glypta (Watson, 1886)

(Plate 1, fig. a, b)

Trochus (Gibbula) glyptus Watson, 1886. p. 75, pl. 6, f. 6. Off Sydney, NSW, 750 m (410 fms).

Diagnosis: Shell large for genus (> 20 mm), low spired and widely umbilicate.

Description: Shell conical and widely umbilicate. Protoconch 1 1/2 whorls, globose; teleoconch 7 1/2 whorls. Spire whorls flatly rounded; sutures slightly impressed. Sculpture axial ribs on first and second whorl, crossed by two spiral rows of nodules. On third whorl, axial ribs fade, leaving only spiral rows of nodules, interstices becoming obliquely axially lamellose. On fourth whorl, top spiral row of nodules becomes enlarged and splits into two spiral rows of nodules at shoulder of whorl. Nodules at widest point of the whorl become more crowded and another row appears at suture. Sculpture on body whorl consists of two rows of nodules at shoulder, space crossed by many oblique axial lamellae and one weak spiral row of nodules and two more spiral rows of nodules at periphery and just above. Base flatly convex with five spiral rows of nodules, narrower than interstices. Last row of nodules surrounding umbilicus. Umbilicus wide, deep; smooth inside. Aperture with thin, slightly flaring outer lip; columella slightly reflected. Colour dull off-white, interior nacreous.

Measurements: (mm)

	h	w	a
Average specimen:	18.5	23.5	8.6

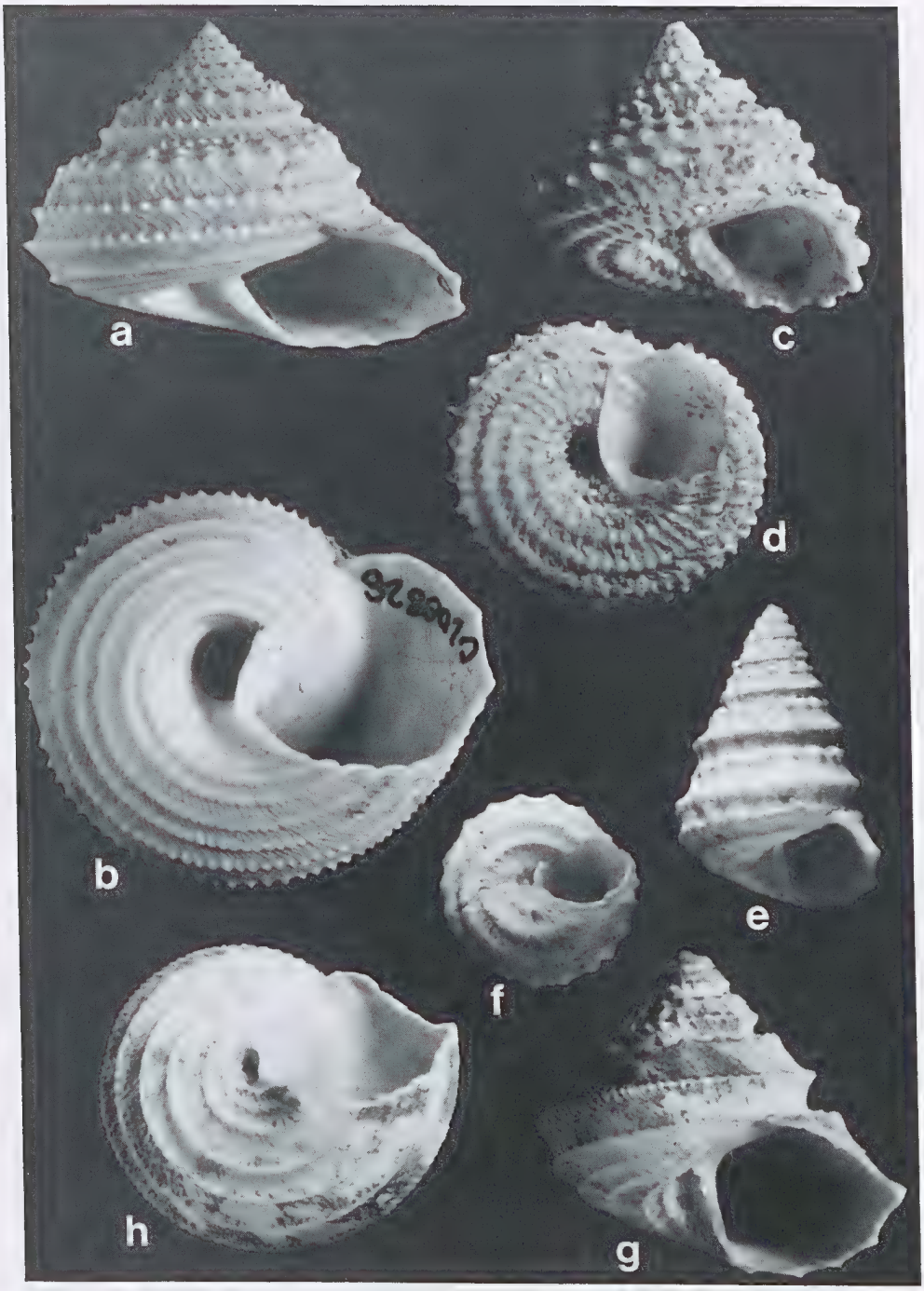

Plate 1. a, b *Calliotropis glypta* Watson, 1886. AMS C100828, off Broken Bay, NSW; c, d *C. echidna* n.sp. Holotype AMS C169582, NE of Cape Moreton, Qld.; e, f *C. acherontis* Marshall, 1979. AMS C169588, E. of Cape Three Points, NSW; g, h *C. canaliculata* n. sp. Holotype AMS C169584, off Sydney, NSW.

Material studied: New South Wales: 36 km. off Broken Bay, NSW, 640 m., 0415 – 0715 hrs, 19 Aug. 1975, 33°25-30'S, 153°03-07'E, mud, 20 m. otter trawl. FRV 'Kapala', K75-05-04, C100828 (1); E of Sydney, NSW, 17 Dec. 1975, 34°48-43'S, 151°48-51'E, 421 m., FRV 'Kapala', K75-12-07, C102869 (4); S. of Sugarloaf Point, NSW, 32°22-17'S, 152°58'E, 457 m., 2 Oct 1975, FRV 'Kapala' K75-08-03, C102824 (4); 32 km. E. of Sydney Heads, NSW, 549 m., C24451 (2); E. of Port Kembla, NSW, 412 m., 34°28-34'S, 151°19-17'E, mud bottom, demersal prawn trawl., 20 Aug. 1975, FRV 'Kapala', K75-05-07, C100862 (1); 24 km. E. of Kiama, NSW, 503 m., 34°36-45'S, 151°16-13'E, 21 Aug. 1975, mud bottom, demersal prawn trawl., FRV 'Kapala', K75-05-08, C100855 (6); 360–640 m., Sydney – Newcastle, NSW, Oct.–Nov. 1973, prawn trawl 'Kapala' (2); NE of Wollongong, NSW, 34°18-24'S, 151°26-21'E, mud bottom, demersal prawn trawl, Aug. 1975, 457–484 m., FRV 'Kapala', K75-05-06, C100845; off Newcastle, NSW, 33°11'S, 152°23'E, 567 m., 29 April 1971, 'Kapala' Stn. 71-08-05, C79205 (2); off Botany Bay, NSW, 24 May 1978, 34°19-17'S, 151°26-27'E, 466 m., trawled, 1300 hrs., 'Kapala' K78-08-03, C123481 (1); E. of Kiama, NSW, 16 Dec. 1975, 34°39-32'S, 151°15-19'E, 412 m., FRV 'Kapala' K75-12-05, C102734 (6); off Brush Is., NSW, 35°41-36'S, 150°40-43'E, 560–595 m., 16 Oct 1986, FRV 'Kapala', K86-28-07; off Wattamolla, NSW, 34°15-19'S, 151°28-26'E, 440–500 m., 3 Sept 1984, FRV 'Kapala', K84-14-01; off Sydney, NSW, 33°46-43'S, 151°51-54'E, 500–550 m., 4 Nov. 1985, FRV 'Kapala, K85-16-01.

Distribution: Off the New South Wales coast, Newcastle to Brush Is.; 366 to 640 m.

Remarks: This species is readily distinguished from the species below by its large size.

Calliotropis echidna n. sp.

(Plate 1, fig. c, d)

Diagnosis: Shell thick for genus; sculpture consisting of very sharp spines; '<' - shaped and reflected columella, with nodule at base.

Description: Shell thick for genus, conical and umbilicate. Protoconch 1 1/3 whorls, transparent; teleoconch 5 3/4 whorls. Spire whorls convex; sutures impressed. Sides of spire concave above and convex below. First whorl with smooth axial ribs, on second whorl two spines start appearing on each axial rib, size of spines increases until on fourth whorl two spiral ribs appear with spines and spines become hollow. On fifth whorl, a weak third spiral rib with spines appears between highest rib and suture. Body whorl with eight spiral ribs with spines, of which four above periphery; lowest two are largest. Base with four spiral ribs, gradually decreasing in size, only outer ones with spines, others with nodules, linked to each other by axial lamellae. Fourth rib set slightly inside umbilicus. Umbilicus with another, smaller rib. Columella resembling a smaller-than-symbol '<', strongly reflected, with small nodule at base. Aperture strongly oblique; outer lip thickened. Colour off-white to grey, interior nacreous.

Variation within the species: Shells vary in height-width ratio (see measurements) and the extent to which the spines are linked by axial lamellae. Northern Territory and New Caledonian specimens have axial streaks of pigmentation and sometimes an

almost smooth band at the periphery. Although these latter populations may prove to represent another, closely related, species. They are referred to as cf. *echidna* below.

Measurements: (mm)

		h	w	a
Holotype:		5.91	6.03	1.76
Paratypes:	largest:	5.91	6.76	2.26
	smallest:	4.79	5.73	1.35

Location of type material: AMS: Holotype C169582 and 17 paratypes C169583.

Type locality: Holotype and paratypes: 115–124 m., NE of Cape Moreton, Qld.

Other material studied: *C. echidna* Queensland: trawled 183 m., NNE of Cape Moreton, Qld., mv. 'Eileen Silva', C169862 (7); 128 – 183 m. off Cape Moreton, Qld., ex trawler, C169869 (4); 115 m. off Cape Moreton, Qld., C71469 (2); 115 – 124 m. off Cape Moreton, Qld., C169869 (6); Capricorn Channel, Great Barrier Reef, Qld., 23°08.6'S, 152°16.6'E, 155 m., dead shell, fine sand and mud, HMAS 'Kimbla', C169861 (2); 92 – 119 m., E. of Caloundra, Qld., C169861 (2); off Fraser Is., Qld, 210 m., coarse calcareous nodules, HMAS 'Kimbla', C169867 (1);E. of Lady Musgrave Is., Qld, 296 m., 23°52.5-51.9'S, 152°42.7-41.7'E, C164221; NE of Lady Elliott Island, Qld., 24°03.7'S, 152°49.4'E, 150 m., HMAS 'Kimbla', C170047 (2); SE of Swain Reefs, Qld., 187 m., 22°26-27'S, 153°17.13-6'E, HMAS 'Kimbla', Stn. 7, C16965 (3), C169860 (5), C169864 (5); 20 km. NE of North Reef, Qld., 115 m., 23°08.4'S, 152°12.3'E, HMAS 'Kimbla', Stn. 20, C169863 (10); off S. end Fraser Island, Qld., 210–219 m., 25°58'S, 153°51'E, sand, brachiopods, bryozoa, HMAS 'Kimbla Stn. Q16, C169871 (6); off Maroochydore, Qld., 26°41'S, 153°38.4'E, dredged ca. 200 m., HMAS 'Kimbla', C169872 (1).

New South Wales: ca. 24 km. E. of Little Bay (Malabar), Sydney, 192–203 m., 33°58'48"S, 151°34'30"E, C169870 (1).

E. cf. *echidna* Northern Territory: Approx. 100 ml. N. of Croker Is., NT, 9°30'S, 132°34'E, 124 m., mv. 'San Pedro Sound'; Arafura Sea, approx. 110 ml. N. of Melville Is., NT, 135 m., 9°34'S, 131°22'E, mv. 'San Pedro Sound'.

Outside Australia: New Caledonia: Sth. New Caledonia, 4 ml. S. of Ile des Pins, 22°50'S, 167°34'E, , coral sand bottom, HMAS 'Kimbla'.

Distribution: *C. echidna*: From off Sydney to Swain Reefs; 115 – 296 m. *C.* cf. *echidna*: Arafura Sea and New Caledonia.

Remarks: The only species of *Calliotropis* previously known from the east coast of Australia is *C. glypta* (Watson, 1886). The new species differs from that taxon by being less than one third in size, thicker-shelled and its sculpture of very sharp spines. The spines are so sharp, that shells often cling to fingers when picked up.

Two species from Indonesia are slightly similar. *C. multisquamosa* Schepman, 1908 is higher spired and and has a straighter, less strongly reflected columella. *C. muricata* Schepman, 1908 is more finely sculptured and has two denticles on the columella.

Etymology: Named after the Australian echidna, because of its very spiny appearance.

Calliotropis acherontis Marshall, 1979

(Plate 1, fig. e, f)

Marshall, 1979. p. 529, f. 3 L–O, 9 A, B.

Diagnosis: Shell elevate-conical, maximum height for studied specimens 6 mm, sculptured with two spiral rows of knobs on each whorl.

Description: Shell elevate-conical and imperforate or with a narrow umbilical chink. Protoconch 1 1/3 whorls, globose; teleoconch 5 3/4 whorls. Spire whorls flat; sutures impressed. First and second whorls with axial ribs. On second whorl, two spines per axial rib start appearing, gradually becoming further apart and axial ribs becoming obsolete on later whorls. Sculpture on body whorl two nodulose ribs, first rib situated just below suture, second rib at periphery and third, much weaker, nodulose spiral rib below periphery, coinciding with suture in earlier whorls. Base with two narrow smooth ribs and one nodulose rib surrounding umbilical area. Columella slightly concave above, straight below and slightly reflected. Interior reflecting sculpture on outside. Outer lip thin; aperture nearly circular. Colour uniform white, interior nacreous.

Variation within the species: This species varies in the number of nodules on the spiral ribs. Some specimens have a very narrow umbilical chink.

Measurements: (mm)

	h	w	a
Average specimen:	5.28	3.78	1.42

Location of type material: NMNZ, MF30816.

Type locality: BS442 (29°16'S, 177°49.5'E, SE of Chanter Islets, Raoul Island, Kermadec Islands, clean pumice and gravel, 512–549 m., RV 'Acheron'.

Material studied: Queensland: E. of Lady Elliott Is., S. Qld., 24°00's, 153°06.5'E, 531 – 476 m., fine grey ooze/sand, HMAS 'Kimbla', C169876 (3); Off Cairns, Qld., 17°09'42"-36"S, 146°42'24"- 42'00"E, 613 – 668 m., firm clay and mud, C170046 (1).

New South Wales: Off Ulladulla, NSW, 549 m., C169874 (5); NE of Seal Rocks, NSW, 32°21-23'S, 152°09'-153°00'E, 457 m., FRV 'Kapala' Stn. K75-07-02, C169875 (1); off Sydney, NSW, 457 m., 33°42-39'S, 151°52-54'E, FRV 'Kapala', C169873; E. of Cape Three Points, NSW, 33°28-29'S, 152°52'E, 457–467 m., FRV 'Kapala' Stn. K79-20-08, C169588 (6); off Sydney, NSW, 457 m., 20 Dec. 1975, 33°42'S, 151°52-54'E, 1430 hrs., FRV 'Kapala', K76-24-01 (2).

Outside Australia: Tasman Sea, Lord Howe Rise, 27°58.99'S, 162°51.55'E, 1250 m., epibenthic sled, coarse sediment with pumice, 'Franklin' Stn. FR6589-29, C166699 (pt.) SC/RC (wet material); off New Caledonia, 19°28'S, 168°53'E, 1025–1100 m., HMAS 'Kimbla', Stn. KI-71-6.

Distribution: On the continental slopes off eastern Australia coast from Cairns, Qld. to Ulladulla, NSW, Lord Howe Rise, Kermadec Islands, New Caledonia; 457 – 1250 m.

Remarks: The elongate conical shape and absence of an umbilicus (in most specimens) are characters of this species which separate it from all other Australian

species of *Calliotropis*. *Calliotropis hondoensis* (Dall, 1881) from Japan is similar in appearance, but is much larger and has more rounded whorls. *Bathybembix japonicus* (Dall, 1925) is much larger and has a different sculpture with three rows of nodules on the penultimate whorl. *Calliotropis tiara* (Watson, 1879) is also a similar, but broader species from off central eastern America (Quinn, 1979).

Calliotropis carinata n.sp.

(Plate 2, fig. a, b)

Diagnosis: The depressed conical shape in combination with the strong, smooth keel and convex base are diagnostic features which separate this species.

Description: Shell depressed conical, widely umbilicate. Protoconch 1 1/4 whorls, smooth, translucent white; teleoconch 4 1/3 whorls, flat; sutures impressed. First and subsequent whorls with axial ribs with two small spines on each axial rib, linked by a fine spiral rib; spines become larger and top spiral rib becomes obsolete in later

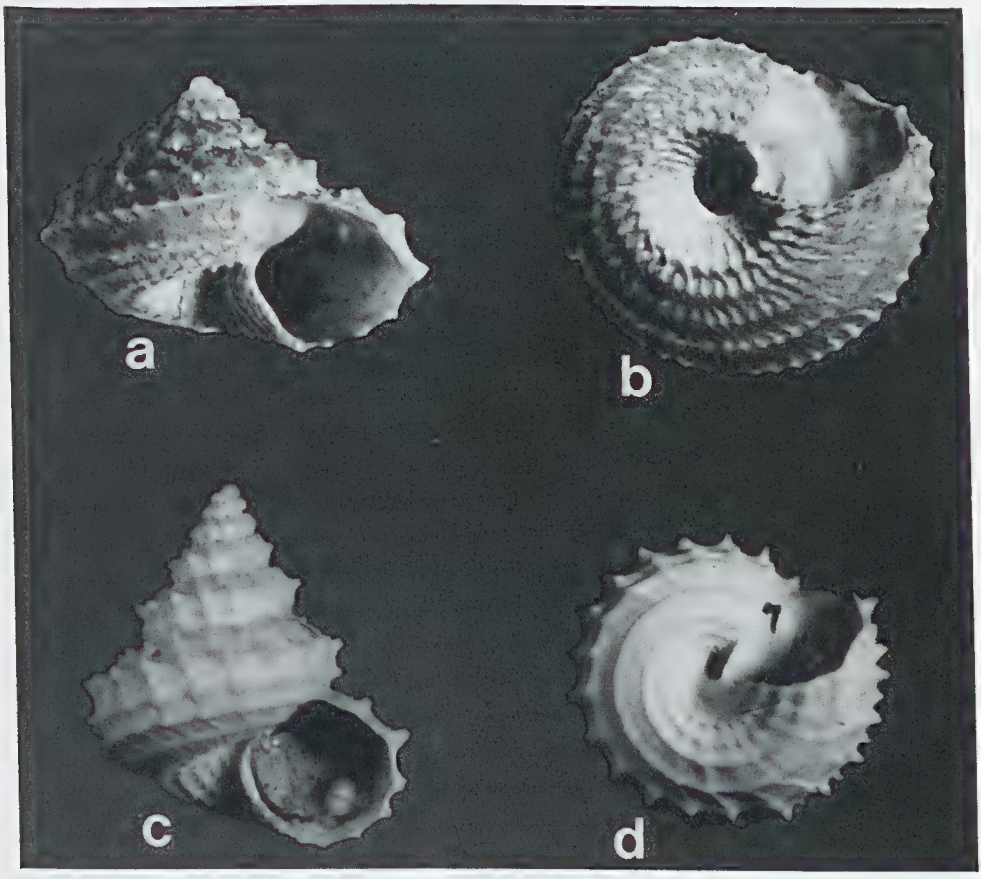

Plate 2. a, b *Calliotropis carinata* n. sp. Holotype, AMS C169586, off Sydney, NSW; c, d *C. lamellifera* n. sp. AMS C169587, off Sydney, NSW.

whorls. Body whorl with three spiral rows of spines, top row not connected by spiral rib. Second and third row of spines have progressively finer spines and stronger spiral ribs; third spiral at periphery, thin and sharp. Whole shell surface finely but irregularly axially striated. Base convex, with four sharply nodulose ribs, lowest one bordering umbilicus. Inside of umbilicus smooth. Columella concave, simple, not reflected. Outer lip thin, following the sculpture on the shell surface. Colour uniform white, interior nacreous.

Measurements: (mm)

		h	w	a
Holotype:		4.22	5.92	1.99
Paratypes:	largest:	5.01	7.15	2.42
	smallest:	3.72	4.75	1.61

Location of type material: AMS: holotype C169586 and three paratypes C169877.

Type locality: Holotype and paratypes: off Sydney, NSW, 33°31-33'S, 152°07-08'E, 940–917 m., FRV 'Kapala', Stn. K80-20-08.

Other material studied: Queensland: NE of Sandy Cape, Qld., 24°25.2-24.6'S, 153°23.5-22.4'E, 830 m., HMAS 'Kimbla' Stn. 16, C170045 (2).

New South Wales: E. of Sydney, NSW, 33°44'S, 151°57'E,, 322 m., FRV 'Kapala', C169881 (1); off Sydney, NSW, 33°35'S, 152°09'E, 1097 m., FRV 'Kapala', C169880 (1); off Sydney, NSW, 33°42'S, 151°55'E, 549 m., FRV 'Kapala', C169879 (1); off Sydney, NSW, 34°05'S, 151°43.6'E, 750 m., sandy mud and fine shell, HMAS 'Kimbla' (9 – damaged/juvenile); off Sydney, NSW, 33°37-39'S, 152°04-02'E, FRV 'Kapala', 924–896 m., C169878 (5).

Distribution: Continental slopes off the eastern coast of Australia from Sandy Cape, Qld. to off Sydney, NSW; 322 to 1097 m.

Remarks: This species superficially resembles *Calliotropis echidna*, but can be distinguished by its convex base, smooth umbilicus and solid, rather than hollow, spines. It also lacks the strong axial lamellae on the base of the shell. *Calliotropis concavospira* (Schepman, 1908) from Indonesia is also similar, but has a more rounded body whorl and a smoother base. *C. calatha* (Dall, 1927) from eastern America is similar, but higher spired and has a more rounded body whorl.

Etymology: *carinatus* (latin) – keeled, referring to the sharp keel surrounding the body whorl.

Calliotropis canaliculata n.sp.

(Plate 1, fig. g, h)

Diagnosis: Shell conical, with chanelled sutures; two sharp keels, the higher with sharp nodules, the lower a spinulose rib.

Description: Shell conical, with straight sides, sharply keeled, narrowly umbilicate. Protoconch 1 1/4 whorl, globose; teleoconch 4 1/2 whorls, carinated; sutures deeply channelled. First and second whorl with sharp axial ribs. Two spines per axial rib

develop on second whorl, bottom ones larger top ones, linked by spiral rib. Axial sculpture fading on third whorl, leaving only two spiral rows of nodules, one at shoulder, one just above suture of next whorl. Nodules on shoulder become larger and more widely spaced and ones above suture of next whorl increase in number and fuse into spinulose rib. Body whorl with two prominent keels, top one composed of large, sharp, upward pointing nodules, with small, horizontal shoulder above. Second keel at periphery, horizontally expanded with small, sharp nodules. Area between keels smooth and flat. Suture below second keel; channel-like. Base with five narrow spiral ribs with sharp nodules. Columella straight, reflected at top, thin at base. Umbilicus narrow. Outer lip sharp and simple; inside smooth. Colour uniform white, interior nacreous.

Measurements: (mm)

		h	w	a
Holotype:		6.82	7.82	2.72
Paratypes:	largest:	7.40	7.60	3.18
	smallest:	6.70	6.35	2.40

Location of type material: AMS: Holotype C169584 and four paratypes C169585.

Type locality: Holotype and paratypes: Off Sydney, NSW, 33°35-37'S, 152°05'E, 1106–1143 m., FRV 'Kapala', Stn. K80-20-10.

Other material studied: New South Wales: Off Sydney, NSW, 33°35-37'S, 152°05'E, 1143 – 1106 m., dredge FRV 'Kapala', C169888 (6); off Sydney, NSW, 33°36'S, 152°09'E, 1079 m., FRV 'Kapala', C169882 (1), C169883 (1), C169884 (1); off Sydney, NSW, 33°37-38'S, 152°04-02'E, 924 – 896 m., FRV 'Kapala', C169886 (2); off Wollongong, NSW, 34°27-26'S, 151°27'E, 1200 m., FRV 'Kapala', C169885 (2); S. of Newcastle, NSW, 33°05.4'S, 152°40.1'E, 1500 – 1700 m., R.V. 'Tangaroa', C170044 (1); off Nowra, NSW, 34°50'S, 151°15'E, 841 m., FRV 'Kapala', C169889 (1).

Distribution: Off the New South Wales coast between Newcastle and Nowra; 841 – 1700 m.

Remarks: This species is similar to *C. pagodiformis* (Schepman, 1908) from the Indonesian Archipelago, but the holotype of that species has larger nodules on the peripheral keel and has four ribs on the base instead of five. *Calliotropis dentata* Quinn, 1991 from the northwestern Atlantic is also similar in appearance, but has a less keeled body whorl and is more openly umbilicate. The species also superficially resembles *C. ottoi* (Philippi, 1844), the type of the genus, but that species has more rounded whorls.

Etymology: *canaliculatus* (Latin) – channelled, referring to the channelled suture.

Calliotropis lamellifera n. sp.

(Plate 2, fig. c, d)

Diagnosis: Shell elevate-conical, with rounded whorls. Sculpture of axial lamellae across spiral ribs, forming spines at intersections, largest on second rib, axial lamellae stop at fourth spiral rib.

Description: Shell elongate-conical, with rounded whorls, narrowly umbilicate. Protoconch 1 1/4 whorls, globose, white; teleoconch 5 2/3 whorls, angulated and rounded; sutures impressed. First whorl axially ribbed. Spines develop on shoulder of second whorl, becoming stronger on third whorl and on fourth whorl two more spiral rows of spines appear, one above and one below existing spiral row, linked by fine spiral ribs. Sculpture strengthening, spines becoming scales in later whorls. Body whorl with three spiral ribs above suture, with narrow, spine-like projections, largest in second spiral, crossed by axial lamellae, coinciding with spines. Axial lamellae stop at fourth, smooth, spiral cord. Base with three or four narrow spiral cords, bearing fine sharp spines. Sculpture continuing into umbilicus. Aperture nearly circular, columella simple, concave, without callus and not reflected. Outer lip thin, with three spines coinciding with ribs on shell surface. Colour completely dull white, interior nacreous.

Measurements: (mm)

		h	w	a
Holotype:		4.84	4.28	1.65
Paratypes:	largest:	4.84	3.86	1.54
	smallest:	3.80	3.21	1.46

Location of type material: AMS: Holotype C169587 and two paratypes C169891.

Type locality: Holotype: Off Sydney, NSW, 33°35-37'S, 152°05'E, 1106-1143 m., FRV 'Kapala' Stn. K80-20-10.

Paratypes: NE of Sandy Cape, Qld., 1330–1380 m., 24°28.2'S, 153°31.2'E, HMAS 'Kimbla' Stn. 17.

Other material studied: Queensland: NE of Sandy Cape, Qld., 1330 – 1380 m., 24°28.2'S, 153°31.2'E, HMAS 'Kimbla' Stn. 17, C169892 (1).

New South Wales: Off Sydney, NSW, 33°42'S, 151°55'E, 549 m., FRV 'Kapala' (2); off Sydney, NSW, 33°35'S, 152°09'E, 1097 m., FRV 'Kapala', C169890 (1); off Sydney, NSW, 33°44'S, 151°51'E, 322 m., FRV 'Kapala' (1).

Distribution: Known only from off Sydney and Sandy Cape, Qld.; 322 to 1380 m.

Remarks: This species is unlike any other Australian species of *Calliotropis*, and is easily recognised by its rounded whorls and delicate spines. *Calliotropis hondoensis* (Dall, 1925) is similar in appearance, but is much larger, more widely umbilicate and does not have lamellae. *Calliotropis multisquamosa* (Schepman, 1908) also has lamellae, but is flatter in shape and does not have rounded whorls.

Etymology: *lamelliferus* (Latin) – producing lamellae, referring to the erect lamellae on the whorls.

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Notes on Australian species of *Euchelus* and *Herpetopoma* (Gastropoda: Trochidae) with descriptions of five new species.

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Five new species of *Euchelus* and *Herpetopoma* are described: *Euchelus dampierensis* from Western Australia, *Herpetopoma corallina*, *H. elevata* from the Great Barrier Reef, *H. norfolkensis* from Norfolk Island and *H. howensis* from Lord Howe Island. *Euchelus* cf. *horridus* (Philippi, 1846) and *Euchelus gemmatus* (Gould, 1845) are recorded from Australia.

Introduction

This paper deals with new species or species not previously reported from Australia belonging to *Euchelus* and related genera (*Euchelus sensu lato*). The southern Australian species of *Euchelus s.l.* are fairly well known, mainly thanks to work by Tate (1893) and Cotton (1959). The northern and western Australian species of *Euchelus s.l.* are much less well-known. In Queensland, there is an overlap with species occurring in the Indo West-Pacific, and species named by workers such as Pease (1863), Crosse (1863), Fischer (1875) and Souverbie and Montrouzier (1875) were studied.

Generic classifications are currently based on shell characters and, while in need of revision, are beyond the scope of this paper. The existing genera as listed in Hickman and McLean (1990) were used. *Euchelus s.l.* was used for species that could not easily be placed in one of the existing genera.

Materials and methods

Material from the collections of the Australian Museum Sydney (AMS) and the Western Australian Museum Perth (WAM) was examined. Characters used in identification were shell shape and general appearance, sculpture, columellar and umbilical features, colour, protoconch and operculum (if available). Shell measurements were taken from terminal growth shells only. Height (h), maximum width (w) and height of the aperture (a) are indicated in mm. Numbers in parentheses behind localities indicate the number of specimens; multiple numbers indicate that there are more than one lot from the same locality.

Taxonomy

Family Trochidae Rafinesque, 1815

Subfamily Eucyclinae Koken, 1897

Tribe Chilodontini Wenz, 1938

Diagnosis: Shells thick and highly ornate; some form of spiral and axial sculpture present in most species; often nodose or lamellose. Inside of aperture with columellar teeth and/or lirae or teeth on outer lip. Inside of shell nacreous. Operculum multispiral but with fewer volutions than that of other trochids (Hickman and McLean, 1990).

Chilodontini live worldwide, but mostly in tropical and subtropical seas and are found intertidally or in the shallow sublittoral.

Genera used for Australian species within this tribe are *Euchelus sensu stricto (s.s.)* Philippi, 1847, *Vaceuchelus* Iredale, 1929, *Herpetopoma* Pilsbry, 1889, *Danilia* Brusina, 1865, *Granata* Cotton, 1957, *Hybochelus* Pilsbry, 1889 and *Turcica* A. Adams, 1854. This paper will deal with the group of genera closely resembling *Euchelus*, which comprises *Euchelus*, *Herpetopoma* and *Vaceuchelus*. These genera are characterised by rounded whorls and impressed sutures (separating them from *Turcica*), with a simple outer lip (as opposed to the thickened outer lip of *Danilia*) and height and width are about equal (as opposed to the low-spired, flat shells of *Granata* and *Hybochelus*).

Of the five new species described here one is placed in *Euchelus s.s.* and four in *Herpetopoma*. One additional species of *Euchelus* is also discussed, as well as one species of *Euchelus s.l.*

A key to the Australian genera similar to *Euchelus*:

Shell > 10 mm, spiral sculpture stronger than axial sculpture, imperforate or perforate, columella tooth absent or small compared to columella length ..... *Euchelus s.s*

Shell < 10 mm, spiral sculpture stronger than axial sculpture, imperforate or perforate, columella tooth large compared to columella length ..... *Herpetopoma*

Shell with strong spiral as well as axial sculpture, imperforate to narrowly perforate, columella without tooth, shell colour mostly white, often with red spots .... *Vaceuchelus*

Genus *Euchelus* Philippi, 1846

Type species *Monodonta tricarinata* Lamarck, 1822.

Euchelus cf. *horridus* (Philippi, 1846)

Plate 1, f. 1, 2

Trochus horridus Philippi, 1846. p. 172, t. 27, f. 12. Pacific Ocean.

Euchelus horridus Pilsbry, 1889. p. 433, pl. 37, f. 17.

Description: Shell rather large and thick. Protoconch missing in all available specimens; teleoconch with four whorls, rounded; sutures deeply impressed. First whorl eroded. Second whorl with two primary ribs and two nodulated secondary ribs above highest primary rib. Third whorl with three secondary ribs, primary rib, secondary rib, primary rib and secondary rib. Last whorl with three primary ribs; above highest of these, up to five secondary ribs, size dependent; one secondary rib between first and second and second and third primary ribs. Lowest of primary ribs coincides with suture in previous whorls. Area below this rib with up to seven irregular secondary ribs. Between all these ribs, even finer ribs may be present. Whole surface of shell, except

for primary ribs, with fine oblique axial lamellae, rendering spiral ribs nodulose. Sculpture further crossed by rough growth lines. Columella smooth, nearly straight, only slightly reflected. Umbilicus round, rather wide; umbilical area smooth. Outer lip weakly crenulate, inside finely lirate in adult shells. Colour mainly dirty purple, primary ribs alternating white and dark purple. Inside of shell and columella white. Umbilicus with tinge of purple.

Type material: Location: not known. Locality: Pacific Ocean

Measurements: (mm)

	h	w	a
Largest specimen	14.05	13.91	6.00
smallest adult specimen	8.19	8.27	3.90

Material studied: AMS: On beach below Crocodile Research Station, Maningrida, NT, beach and rocks (4, 7); Rocky reef, below Crocodile Research Station, Maningrida Arnhem Land, NT, on *Sargassum* (1 juvenile); on *Sargassum*, Melaka, W. Malaysia, on sheltered sand/mud flats (1, 1, 1)

Distribution: *E.* cf. *horridus*: Northern Territory; Malaysia.
E. horridus: India (Rajagopal and Mookherjee, 1978); Karachi (Melvill and Standen, 1901); Mediterranean (Rajagopal and Mookherjee, 1978).

Discussion: It is not possible to positively identify this species as *E. horridus* in the absence of type material. The Australian and Malaysian shells match the original description and illustration given by Pilsbry (1889) except that they do not have a denticle on the columella.

A similar species found in Karachi and the eastern Indian Ocean is *Euchelus asper* (Gmelin, 1791), which differs by being larger and imperforate and having closely packed secondary ribs in the interstices between the primary ribs. *E. circulatus* Anton, 1848 is also similar, but differs in having more primary ribs. *E. scaber* Fischer, 1878 differs in having three primary ribs on the penultimate whorl instead of two, and is white with red colouration instead of dark purple.

Euchelus dampierensis n. sp.

Plate 1, f. 3, 4

Description: Shell medium-sized, high-spired for genus, umbilicate. Protoconch consisting of 1 1/4 whorls; teleoconch with 4 to 5 whorls, rounded, sutures impressed. Shell always taller than wide. Protoconch black or white, terminated by a varix. First whorl with only small, curved, axial ribs. Second whorl with two fine spiral ribs, becoming nodulose. Third to fifth whorls with increasing number of spiral ribs until seven to eight equally spaced primary spiral ribs with one smaller secondary rib in interstices on body whorl, some specimens with primary and secondary ribs equal in strength, some with additional finer ribs in interstices. Interstices as wide as primary ribs, deeply excavated, crossed by axial, oblique lamellae, forming nodules at intersections with spiral ribs. Columella slightly concave, with small tooth. Umbilicus open, round, surrounded by smooth rib. Outer lip crenulate; lirate inside. Operculum

thin, circular, multispiral with a large last spiral. Colour mainly white, heavily and regularly mottled with brown. Apex black in some specimens. Shell interior nacreous, except white outer lip.

Type material: Holotype AMS C169482: Weld Is., WA, beach. Paratypes WAM 53–92: Learmonth, Exmouth Gulf, WA; 3 adult specimens, 1 juvenile.

Measurements: (mm)

	h	w	a
Holotype:	11.33	9.34	3.74
Paratypes:	11.47	8.66	3.55
	11.50	9.50	4.25
	7.16	6.21	3.20

Other material studied: AMS: Western Australia: South Cowaramup, on beach C169761 (1); off side road, 27 km S. of Exmouth town, on sand/stone flats C169754 (2); Broome, C69100 (1); Exmouth, beach opposite US base, N. of town towards Bundegi Reef C110617 (2); off side road, 27 km S. of Exmouth, on sand/stone flats C169753 (1); Broome, C169758 (1); Pt. Ganthaume, Broome, C169756 (1, encrusted with sponges); under rocks on reef, Pt. Hedland, C 169759 (1); N. side of Naval base, Exmouth, shallow extensive rock pools, 1/2 way across flats inside Bundegi Reef C169755 (1); Horrock's Beach, on limestone platform C 105914 (2), C169757 (1); E. side of Exmouth township, low to mid tide C169755 (2); Denham, Shark Bay, 3/4 – 1/2 km from shore, 1 – 3.5 m. on *Posidonia & Cymadocea* C169749 (1 juvenile); Reef between Roebuck Bay and Broome, C169760 (1); Denham, Shark Bay, C69330 (3); Useless Inlet, Shark Bay, C69249; Pelsart Is., Abrolhos Is., C69320 (1); Exmouth, C169750; Shark Bay, C69361; Useless Inlet, Shark Bay, dredged C169751 (4); Pt. Hedland, C169752 (2). WAM: Western Australia: Kalbarri, WAM53–92 (10); dredged off Cottlesloe, WAM54–92 (1).

Distribution: Western Australian coast from South Cowaramup to Broome, but more common in tropical areas; intertidal and shallow water, often washed ashore on beaches.

Etymology: Named after the Dampierian zoogeographical province.

Discussion: This common shell has probably remained unnamed because of its resemblance to *Euchelus aspersus* (Philippi, 1846). The new species can be separated from *E. aspersus* in its relatively high spire, less crowded, larger spiral ribs with much deeper interstices and by its umbilicus. In the Western Australian Museum, specimens belonging to this species were labelled *E. lischkei* Pilsbry, 1904. This well-known Japanese species is much lower spired, entirely brown and has much broader spiral ribs. Some specimens resemble *E. atratus* (Gmelin, 1791), but that species is much larger (height up to 26 mm vs. 12 mm), has more widely spaced and equal spiral ribs, weaker axial sculpture and is uniform dark purple. *E. rubrus* A. Adams, 1853 is much finer sculptured, has a stronger columellar denticle and is uniform red.

Genus *Herpetopoma* Pilsbry, 1889

Type species *Euchelus scabriusculus* Angas, 1867.

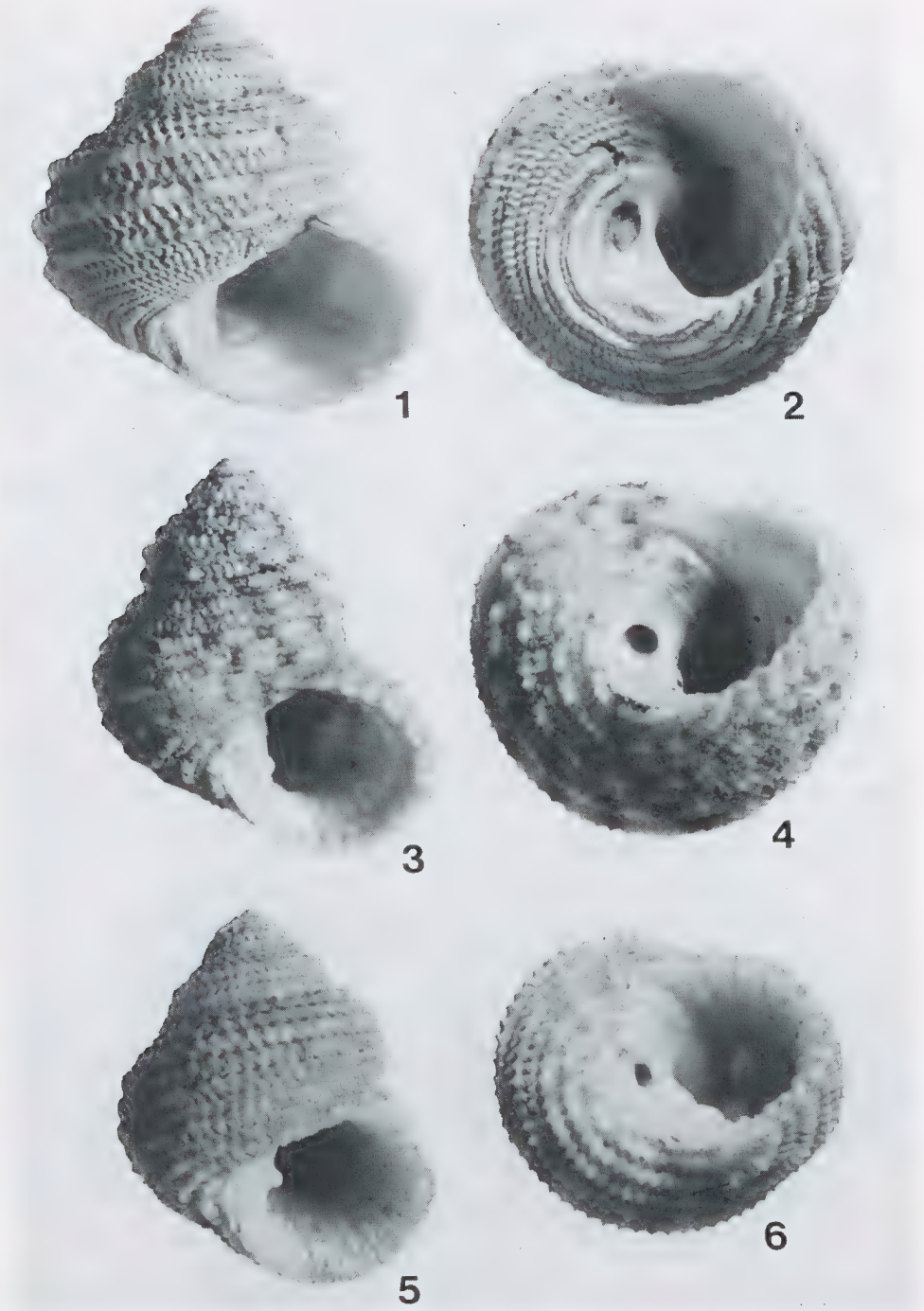

Plate 1. 1, 2 *Euchelus* cf. *horridus* (Philippi, 1846). Beach below Crocodile Research Station, Maningrida, Arnhem Land, NT, beach and rocks; 3, 4 *Euchelus dampierensis* n. sp. holotype; 5, 6 *Euchelus gemmatus* (Gould, 1845). Low Isles near Port Douglas, Qld.

Herpetopoma corallina n. sp.

Plate 2, f. 1, 2

Description: Shell small, thick, triangular, imperforate, sutures channelled. Protoconch 1 1/3 whorl, pitted. Teleoconch with 3 1/4 – 3 1/2 whorls. First whorl strongly axially ribbed. Two nodulose spiral ribs appear on second whorl, one just above suture, one in middle, a third appearing at about 2 1/4 whorl. Spiral ribs increasing in size until at about 3 1/4 whorl a fourth rib appears between first and second rib from above. Last whorl with four spiral rows of strong, sharp nodules above periphery, lowest slightly larger than top three, and forms prominent keel at periphery. Base with 5 smaller progressively less nodulose ribs; ones closest to umbilical area nearly smooth. Interstices between spiral ribs crossed by orthocline axial ribs, more or less continuous with nodules on ribs. Columella broad and reflected over umbilicus, almost totally closing it. Columella with small tooth, and rounded notch below. Outer lip undulated by ribs on outside, inside of aperture strongly lirate. Colour white, maculated with red below sutures.

Type material: Holotype AMS C169484 and three paratypes AMS C169485: Between South Is. and Bird Is., Lizard Is., Qld., 3 m.

Measurements: (mm)

		h	w	a
Holotype:		2.83	2.59	0.70
Paratypes:	largest:	2.68	2.50	0.76
	smallest	2.23	2.21	0.66

Other material studied: AM: Queensland: Euston Reef, off Cairns, 21 m., at bottom of sandy slope below steep coral walls, SW side of reef C169763 (13); Heron Is., Capricorn Group, 16 m. C169766 (1); Michaelmas Cay, off Cairns; Murray Is., 9 – 14.5 m. C48407 (14); Lady Musgrave Is., Bunker Group, dredged in lagoon C169765 (1); SE Heron Is., Capricorn Group, 3.5 m. C169762 (1); Yule Detached Reef 11°59'S, 143°58'E, rubble washings 15–9 m., outside face, S. end C169767 (1).

Distribution: Great Barrier Reef from Lady Musgrave Island, Capricorn Group, southern Barrier Reef to Lizard Island, North of Cooktown; 3 to 21 m.

Etymology: Latin *corallinus* = red, referring to the red spots on the top of the whorls.

Discussion: This species is different from all other species of *Herpetopoma* known in Australia because of its triangular shape and keeled body whorl. *'Euchelus' fimbriatus* Pease, 1861 from Hawaii is slightly larger, has a uniform white colour and is more rounded.

Herpetopoma elevata n. sp.

Plate 2, f. 3, 4

Description: Shell small, relatively thick, high spired and imperforate. Protoconch 1 1/3 whorls; teleoconch with 4 1/2 – 5 whorls, rounded, sutures deeply impressed. First whorl (eroded in all specimens) appears to have broad axial ribs. Second whorl with two spiral ribs, one above suture and in middle of whorl. Third and fourth whorl with

three spiral ribs; top rib smaller than bottom two. Last whorl with two spiral ribs of strong, nodules in middle of whorl, with narrower spiral rib consisting of smaller nodules above. Interstices slightly wider than ribs and with axial, broad, oblique ribs. Base with four smaller nodulose ribs, slightly more than their own width apart; nodules becoming obsolete toward umbilical area. Columella nearly straight, with small knob above notch at base; knob variable in strength. Outer lip undulate (result of external sculpture), dentate inside. Colour uniform white.

Type material: Holotype AMS C169486 and paratype AMS C169487: Euston Reef, outer Barrier Reef off Cairns, Qld. 21 m., at bottom of sandy slope below steep coral walls, SW side of reef.

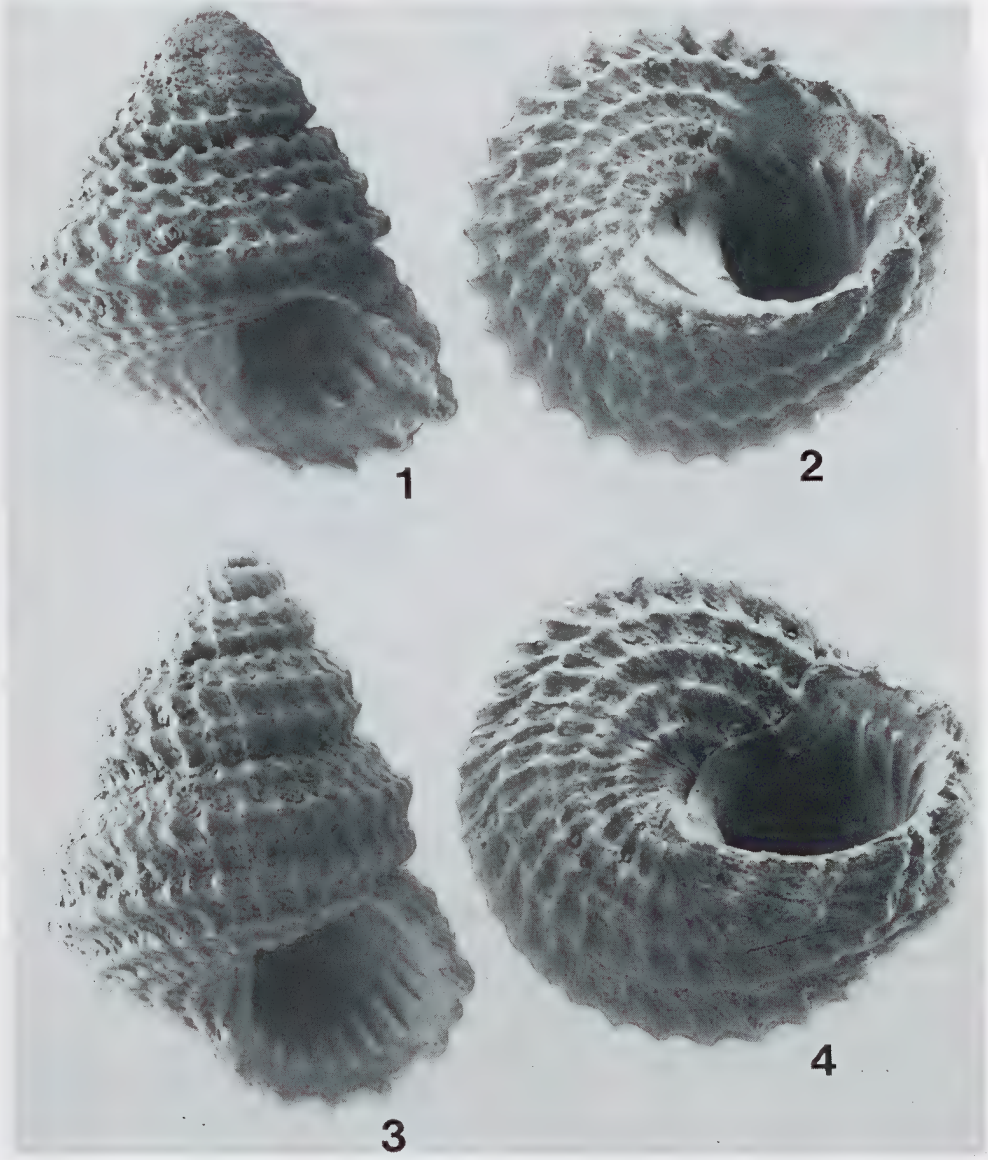

Plate 2. 1, 2 *Herpetopoma corallina* n. sp., holotype; 3, 4 *Herpetopoma elevata* n. sp., holotype.

Measurements: (mm)

	h	w	a
Holotype:	3.56	2.58	0.94
Paratype:	3.18	2.41	1.00

Other material studied: AMS: Qld.: N. end, Carter Reef, 14°33'S, 145°36'E, outer face, coral rubble 27–30 m., C169808 (1); 3 km NE of Gillett Cay, Swains Reef, 64 – 73 m. C169809 (4); Gillett Cay, Swain Reefs, 27–37 m., dredged inside reef, coral rubble C169810 (5); Yule Detached Reef, rubble washings, 15 – 9 m., outside face, S. end C169811 (1).

Distribution: Great Barrier Reef from Gillett Cay, Swain Reefs, off Central Qld. to Yule Detached Reef off N. Qld.; 9 to 80 m.

Etymology: Latin *elevatus* = elevated, referring to the high spire.

Discussion: *H. fenestrata* (Tate, 1893) is a similar species, restricted to south-western Australia and differs from *H. elevata* in being more angulate and having fewer spiral ribs on the body whorl. '*Euchelus' fimbriatus* Pease, 1861 from Hawaii has four spirals on the last whorl and does not have rounded whorls.

Herpetopoma norfolkensis n. sp.

Plate 3, f. 1, 2

Description: Shell small, thick, rounded and imperforate, even in juvenile specimens. Protoconch 1 1/3 whorl, pitted; teleoconch with 3 3/4 whorls, flatly rounded, sutures slightly impressed. First whorl with axial ribs, two spiral ribs appear at 1/2 whorl. Early in second whorl third rib appears at suture above other ribs; at end of second whorl, fourth rib appears between first and second ribs. Third whorl with four spiral ribs. Last whorl with eight spiral ribs, four above periphery, closely crowded with nodules, linked across interstices by orthocline axial ribs, interstices forming deep narrow pits, especially clear in beachworn specimens. Columella straight, reflected, with small tooth at its base and four small nodules at reflected area. Outer lip sharp; inside with strong lirae. Colour off-white, sometimes maculated with red or pink.

Type material: Holotype AMS C169480: Norfolk Island. Paratype AMS C 169481: Emily Bay, Kingston, Norfolk Island, short mixed algae from rock platform.

Measurements: (mm)

	h	w	a
Holotype:	5.22	4.99	1.79
Paratype:	4.45	4.66	1.43

Other material studied: AM: Bumbora Beach, Norfolk Is. C169819 (11); Bumbora Beach, N. side of Norfolk Is., shell sand C169820 (4); Beefsteak Bay, Norfolk Is., shell sand C169813 (5); Norfolk Is., S. Pacific, dredged C169817 (1); 31 m., off Duncombe Bay, Norfolk Is. C169821 (1 juvenile); Point Hunter Reserve, Norfolk Is., E. of cemetery, stone washings, low tide C169818 (1); Point Hunter Reserve, Norfolk Is., under calcarenite rocks to E. of cemetery, mid-tide C169822 (1 juvenile); Emily Bay, Kingston, Norfolk Is., S. side, stone washings from rock platform, low tide C169815 (1 juvenile); Norfolk Is. C169814 (12); Norfolk Is. C169816 (1); Norfolk Is C169823 (2);

Norfolk Is C169824 (8).

Distribution: Known only from Norfolk Island; intertidal to 31 m.

Etymology: Named after Norfolk Island.

Discussion: This species is similar to *'Euchelus' gemmatus* (Gould, 1845), but differs in being imperforate (even in juveniles), in having fewer spiral ribs, which are more equal in size and have more crowded nodules. The interstices are more strongly ribbed and the axial ribs are not oblique as in *E. gemmatus*. *'Euchelus' pauperculus* Lischke, 1872 is also similar to the new species but differs in having much more distantly nodulated spiral ribs and larger spaces between the axial ribs. Also, it is maculated with black and does not have a columella tooth. The new species also has some resemblance to *H. annectans* (Tate, 1893) from south-western Australia, but that species has more spiral ribs and fewer axial lamellae.

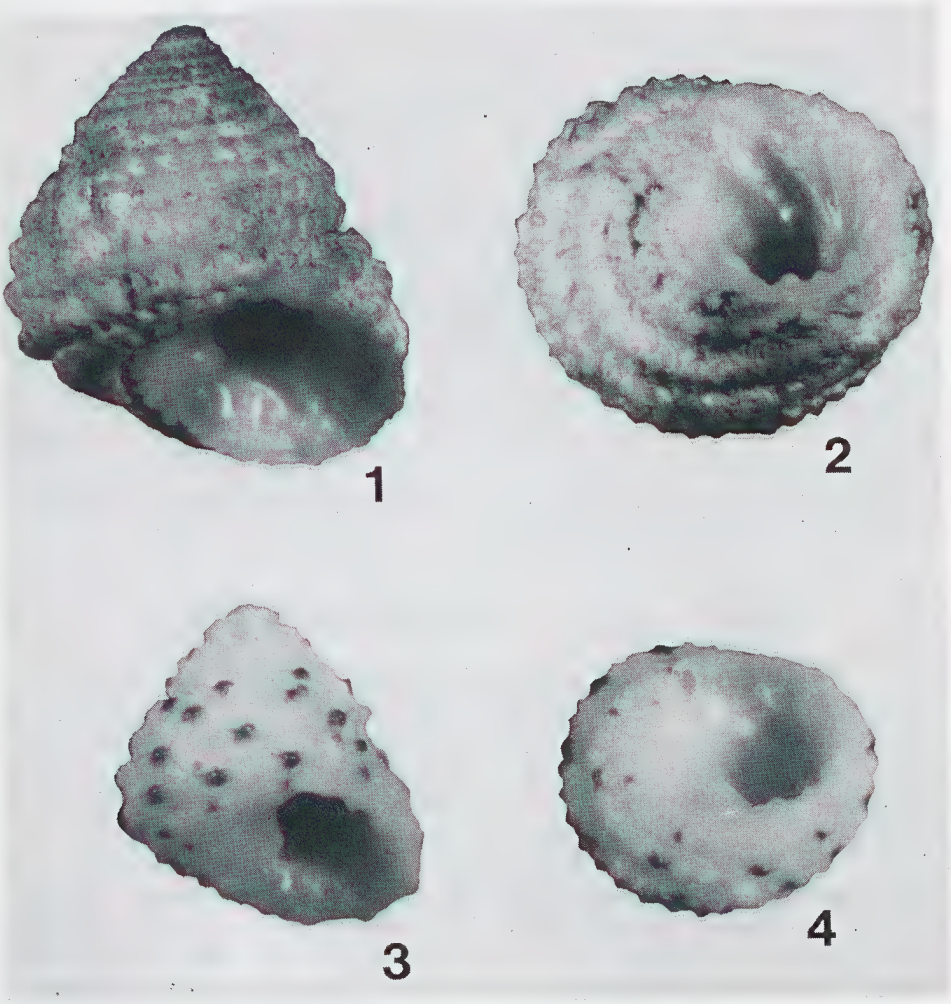

Plate 3. 1, 2 *Herpetopoma norfolkensis* n. sp., holotype; 3, 4 *Herpetopoma howensis n. sp.*, holotype.

Herpetopoma howensis n. sp.

Plate 3, f. 3, 4

Description: Shell small, thick, imperforate. Protoconch missing in all specimens; teleoconch with 3 3/4 whorls. Sides of spire straight; sutures slightly incised. First two whorls eroded, penultimate whorl with three spiral ribs, increasing to four spiral ribs above periphery on last whorl; with smaller spiral ribs in interstices. Base of shell with two larger and two smaller spiral ribs. Spiral ribs nodulose, with small oblique axial ribs linking nodules. Inside of outer lip lirate. Columella with small tooth. Colour white, with purple spots on spiral ribs.

Location of type material: Holotype AMS C169581 and nine paratypes AMS C169825.

Type locality: Holotype AMS C169581: Off Neds Beach, Lord Howe Is., 1 – 2 m., at low tide, algae washings. Paratypes AMS C169825: Lord Howe Island.

Measurements: (mm)

		h	w	a
Holotype:		3.90	3.68	1.30
Paratypes:	largest:	3.82	3.72	1.26
	smallest:	2.96	3.46	1.26

Other material studied: AMS: NE side Lord Howe Is. S. Pacific, dredged in up to 27.5 m. C169826 (1), C169828 (4); Lord Howe Is. C169827 (2).

Distribution: Lord Howe Island, intertidal to 27.5 m.

Etymology: Named after Lord Howe Island.

Discussion: This species is similar to *Herpetopoma pumilio* (Tate, 1893) from Western Australia, but is much larger and has oblique axial sculpture as opposed to orthocline ribs in *H. pumilio*. *H. norfolkensis* differs in being larger (height 5.2 vs 3.9 mm), having a more crowded sculpture, especially in the intersices of the ribs, and lacking the typical purple spots on the ribs.

Genus *Euchelus* Philippi, 1846 *s.l.*

Euchelus gemmatus (Gould, 1845)

Plate 1, f. 5, 6

Trochus gemmatus Gould, 1845. p. 27. Hawaiian Islands.

Trochus fischeri Montrouzier, 1866. p. 142, t. 6, f. 7. New Caledonia.

Euchelus gemmatus Kay, 1979. p. 51, f. 13, 14E.

Description: Shell small, thick, umbilicate. Protoconch white, 1 whorl. Teleoconch with 4 1/2 – 5 whorls, rounded; sutures deeply impressed. First whorl closely axially ribbed. Two spiral ribs appear at 3/4th whorl, one just above suture, one just below middle of whorl, increasing in size on second whorl. At third whorl ribs start appearing in interstices until 10 – 12 spiral ribs on the last whorl, often with smaller ribs in

smaller ribs in interstices; five ribs above periphery. Interstices between ribs narrower than ribs, crossed by fine oblique axial ribs, coinciding with nodules, areas in between forming shallow rhomboic pits. Columella convex with large tooth above deep notch below. Umbilicus narrow, deep, surrounded by strong rib. Outer lip crenulated by ribs on outside; lirate inside. Colour dirty off-white to yellowish, maculated with large spots of brick-red, this pattern continuing on base of shell.

Remarks: Some specimens, referred to below as cf. *gemmatus* are very similar to this species and differ only in being smaller, lighter in colour and having a slightly narrower umbilicus. However, these characters are not consistent enough to separate them as separate species.

Type material: Lectotype: MCZ 169169 New York State Museum, Albany, New York, USA: Sandwich (Hawaiian) Islands

Measurements: (mm)

	h	w	a
E. gemmatus			
Largest specimen:	9.16	7.58	3.03
smallest specimen:	4.27	3.98	1.35
E. cf. *gemmatus*			
largest specimen:	5.38	5.06	2.45
smallest specimen:	3.55	3.49	1.43

Material studied: *E. gemmatus* AMS: Australian material: Queensland: Stover Bay near Somerset, Cape York Peninsula C105683 (1); Reef W. side Prince of Wales Is., Torres Straits C109728 (1); Great Detached Reef, 7 m., coral sand gutter, seaward face C169483 (1); near Raine Is. C169830 (1); Low Isles near Pt. Douglas C169836 (14); 4 mile beach, Pt. Douglas C169829 (1); Murray Is., 9 – 14.5 m., Torres Straits C29933 (1); Mission Beach near Tully, beach C169834 (1 damaged).

Northern Territory: patch reef, N. side, 10 m., coarse shelly sand, New Year Is., NT C169831 (1); Off Pt. Charles, Darwin, NT, 27 – 36.5 m. C169832 (2);

Western Australia: WAM. W. side of Kendrew Is., near Dampier, WA (1)

Outside Australia: AMS. Tarawa, Kiribati (Gilbert Group) C8916 (2); New Caledonia: Noumea C3735 (1); Panie C4103 (1); Poindimie C169835 (1).

E. cf. *gemmatus*: Australian material: AMS: Qld.: Yonge Reef, E. of Lizard Is., 15 – 17 m., outer face, N. end C169839 (1); Michaelmas Cay, off Cairns C169840 (2); North West Is., Capricorn Group C169837 (1); Euston Reef, outer Barrier Reef, 21 m. at bottom of sandy slope below steep coral walls, SW side of reef C169841 (4); inner side of Carter Reef, off 'Platform bommie' C169842 (3), C169843 (1); Michaelmas Cay off Cairns, Qld., A53524 (5); Reef 21–230, Swain Reefs, 21°12'S, 152°20'E, 13–15 m., silted rubble wash in 'Blue Hole' C169838 (1).

Outside Australia: Point Bolton, Abaiang, Kiribati (North Gilbert Is.), 10 m., leeward reef slope, sand sievings C169844 (1).

Distribution: North West Is., Capricorn Group, S. Qld. to Kendrew Is, near Dampier, WA; intertidal to 40 m.; New Caledonia; Kiribati; Hawaii (Kay, 1979).

Discussion: Although commonly found washed ashore on beaches, this species has not previously been recorded from Australia. It is often found in conjunction with another small trochid species *Clanculus granosus* Brazier, 1877, to which it bears some superficial resemblance. The shell is variable in height, the strength of the columellar tooth and in the width of the umbilicus.

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A new species of *Calliostoma* from New Zealand (Mollusca: Gastropoda: Trochoidea)

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Calliostoma (Maurea) simulans n.sp. is described.

Key words: Trochoidea, *Calliostoma*, new species

Introduction

With the advent of commercial scampi trawling on the Chatham Rise, New Zealand, during recent years, a number of undescribed invertebrates have been obtained as bycatch, among them the large calliostomatinae described below. This species resembles some forms of *Calliostoma (Maurea) blacki* (Powell, 1950), which has overlapping geographic and bathymetric ranges, and with which it is locally sympatric. It was to have been named in a revision of the New Zealand Calliostomatinae, currently in progress, but recent requests for identification of scampi bycatch animals have increased the need for a specific name.

Abbreviations and text conventions

MNZ, Museum of New Zealand, Wellington; NZOI, National Institute of Water and Atmospheric Research, Wellington; P, primary spiral cord; S, secondary spiral cord.

Spire angle measurements of individual shells were averaged to reduce bias produced by cyrtoconoid spire outline and increased or decreased expansion rate of the last adult whorl. Spiral sculptural elements on shells are numbered consecutively adapically to abapically as defined by Ikebe (1942) and Marshall (1988).

Systematics

Order Vetigastropoda Salvini-Plawen, 1980

Superfamily Trochoidea Rafinesque, 1815

Family Trochidae Rafinesque, 1815

Subfamily Calliostomatinae Thiele, 1924

Genus *Calliostoma* Swainson, 1840

Calliostoma Swainson, 1840. Type species (by subsequent designation of Herrmannsen, 1846): *Trochus conulus* Linnaeus, 1758; Recent, north-eastern Atlantic and Mediterranean.

Subgenus *Maurea* Oliver, 1926

Maurea Oliver, 1926. Type species (by original designation): *Trochus tigris* Gmelin, 1791; Recent, New Zealand.

Calliostoma (Maurea) simulans n.sp.

Plate 1, figures 1–3

Description: Shell up to 52.5 mm high, most specimens slightly broader than high, rather thin, anomphalous, glossy, spire 1.0–1.5 x higher than aperture, evenly conical, mean spire angle 66–81°. Protoconch and first teleoconch whorl white. Subsequent whorls either white with pale yellowish brown spots between nodules; or spiral interspaces pale pink through translucent pale buff or almost colourless outer shell layer, and spiral cords alternately spotted with white and yellowish or reddish brown. Protoconch 420–430 μm wide, sculptured with network of crisp threads that enclose hexagonal spaces, terminal varix strong. Teleoconch of up to 8.75 strongly and rather evenly convex whorls, suture well impressed, periphery rounded, base weakly convex. First 0.2 whorl delineated by a growth scar, with 2 axial costae and fine spiral threads. Subsequent spire whorls sculptured with spiral cords that multiply by intercalcation from 4 (P1–P4) to 6 (P1–P4, S1, S2) or, a few specimens 7 by addition of S3; summit

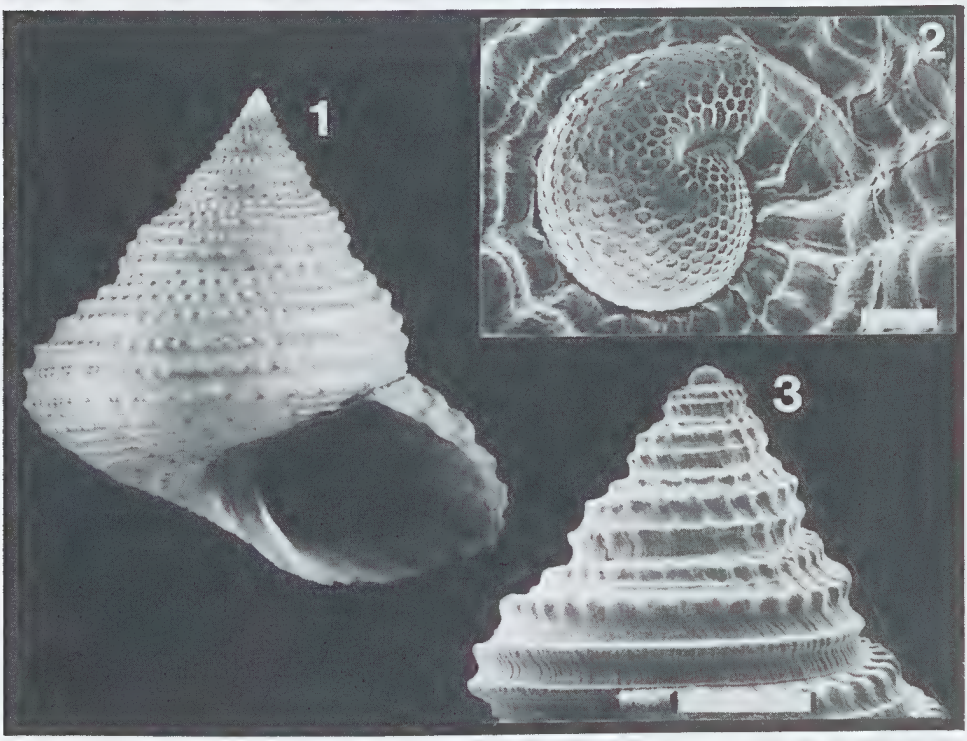

Plate 1. Figures 1–3. *Calliostoma (Maurea) simulans* n.sp. Figure 1. Holotype, shell height 30.5 mm. Figure 2. Protoconch of paratype, Pegasus Canyon, 329–183 m, MNZ M.64654. (scale 100 μm). Figure 3. Early spire whorls of paratype, Pegasus Canyon 329–183m, MNZ M.64654 (scale 1mm).

of P4 partly or in a few specimens entirely exposed on spire, nodules rounded; spiral interspaces considerably wider than each spiral cord, becoming finely spirally lirate. P1–P4 commencing immediately. P1 at first much weaker than P2 and P3, which are strong and similar throughout, gradually enlarging to resemble them or remaining slightly weaker throughout. S1 and S2 becoming as large as P1–P4, S1 commencing on late fourth or mid fifth whorl, S2 commencing on mid fourth or early fifth whorl. Where present, S3 seldom becoming as large as P4. On many specimens P1–P3 nodular at first; P3 becoming weakly nodular or smooth late on fourth whorl on many specimens, becoming strongly nodular again after a further 1–3 whorls. S1 and S2 rapidly becoming nodular, or S2 becoming nodular 1 or 2 whorls from its inception. Basal cords similar to those above, numbering 6–9, weaker and more weakly nodular than those on spire; inner 2 or 3 strongest, nodular; outer spirals more weakly nodular or smooth, weaker or more or less obsolete; interspaces considerably wider than each spiral cord, finely spirally lirate. Axial costae strong on first 2 or 3 whorls, obsolete thereafter. Aperture ovate, inner lip thickened, parietal glaze very thin, outer lip thin and simple.

Type data: Holotype MNZ M.87450 (height 30.5 mm, width 29.0 mm, 8.3 teleoconch whorls) and 33 paratypes MNZ: BS 558, 43°30'S, 173°31.3'E, head of Pegasus Canyon, NE of Banks Peninsula, alive, 27 September 1976, r.v. *Acheron*. Paratypes (158 MNZ): BS 786, 43°25'S, 173°26'E, wall of Pegasus Canyon, alive, 329–183 m, 21 February 1979, r.v. *Acheron* (35); BS 785, 43°25'S, 173°26'E, Pegasus Canyon, alive, 485–476m, 21 February 1979, r.v. *Acheron* (59); BS 784, 43°29.5'S, 173°30.5'E, Pegasus Canyon, alive, 402–338m, 21 February 1979, r.v. *Acheron* (12); BS 783, 43°31'S, 173°30.5'E, Pegasus Canyon, alive, 256–293m, 21 February 1979, r.v. *Acheron* (52).

Other material examined: 3 specimens in 3 lots MNZ, and 28 specimens in 13 lots NZOI.

Distribution: Challenger Plateau, off New Plymouth, off Cape Palliser south to Banks Peninsula, Chatham Rise, and off Bounty and Campbell Islands, New Zealand, 183–1006 m, taken alive at 256–410m.

Remarks: *Calliostoma (Maurea) simulans* most closely resembles *C. (M.) blacki* (Powell, 1950), from which it differs in having more strongly convex teleoconch whorls, and in that spiral cord S1 consistently becomes as large as P1 or larger. By contrast, in *C. (M.) blacki* S1 seldom becomes as large as P1, and the nodules on P1 are consistently larger than those on S1 before the last adult whorl. The two species have overlapping geographic and bathymetric ranges, *C. blacki* occurring on the Chatham Rise, off the east coast of the South Island from Pegasus Bay southwards, and off Stewart, Snares, Auckland, Campbell and Bounty Islands (material MNZ and NZOI). The two species have been obtained living together in dredgings from off Pegasus Bay, Campbell Island, and the Bounty Islands.

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A revision of the Recent Australian species of the turrid genera *Inquisitor* and *Ptychobela*

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Recent Australian species of the genera *Inquisitor* and *Ptychobela* are revised, and many species previously included in *Inquisitor* are excluded. A total of 13 species are recognized in *Inquisitor*, including two described as new from Western Australia, and two species are recognized in *Ptychobela*. *Pleurotoma torresiana* Smith, 1884 is considered to be a synonym of *I. sterrha* (Watson, 1881); *Brachytoma alma* Thiele, 1930 is synonymized with *I. lassulus* Hedley, 1922; and *I. fibratus* Hedley, 1922, *Drillia hololeuca* Odhner, 1917 and *Drillia spaldingi* Brazier, 1876 with *I. spicata* Hinds, 1843. *Inquisitor sterrha* is recorded for the first time from southern Indonesia and southern Papua New Guinea.

Keywords: *Inquisitor*, *Ptychobela*, revision, Australia

Introduction

The family Turridae *sensu lato* is the largest of the all the molluscan families, with Kilburn (pers. comm.) estimating that there are over 5,000 Recent species and Bouchet (1990) showing that there have been 679 genus group names proposed; Taylor *et al.* (1993) recognise 337 genera and subgenera as valid. Over 10,000 nominal Recent and fossil species have been described. Classification at both the species and generic levels within the Turridae has been chaotic, with little recent revisionary work having been done on this vast family. However recent published and unpublished anatomical data, particularly relating to the structure of the foregut, have been analyzed by Taylor *et al.* (1993). Their analysis reconstructed the Conoidea, restricting the Turridae, erecting new families and transferring some taxa to the Conidae. Subsequently Taylor (in press) has provided additional information on the foregut anatomy of several species.

The only complete revision of Australian turrids is the work of Hedley (1922). Since Hedley's paper appeared the primary works on the family in Australia have been by Laseron (1954) for New South Wales, and the Indo-Pacific revisions of the Turrinae and Turriculinae by Powell (1964, 1966; 1969). In the last few years Kosuge (1985–1993) has recorded a number of Recent turrids from the deep waters of the continental slope on the margins of the North West Shelf off northern Western Australia. Powell (1944), Cotton (1947b) and Long (1981) provided the major works on fossil Australian turrids.

The present paper is the fifth in a series revising the Australian Recent Turridae. The first four papers (Wells, 1990; 1991a; 1991b; 1993) examined all of the drilliine genera occurring in Australia except the small genus *Iredalea*. The present paper revises the crassispirine genera *Inquisitor* Hedley, 1918 and *Ptychobela* Thiele, 1925. The status of the two genera has been uncertain, with Powell (1966) regarding

Ptychobela as a synonym of *Inquisitor*, and Shuto (1969) considering *Ptychobela* to be a subgenus of *Inquisitor*. Springsteen and Leobrera (1986) and Kilburn (1988) separated the two on the basis of radular morphology. The problem was examined in detail by Kilburn (1989), who showed that they are in fact distinct genera. However, the basic differences between the genera are in the structure of the radula. In the absence of live collected specimens from which to obtain radulae the assignment of Australian species to either *Inquisitor* or *Ptychobela* must be regarded as tentative. Taylor *et al.* (1993) placed both genera in the family Turridae, subfamily Crassispirinae.

Methods

Type material has been sought wherever possible from the museum in which it is deposited. Most of the nontype material examined is at the Australian Museum, Sydney. A secondary source has been the Western Australian Museum, Perth. The collections of the Queensland Museum, Museum of Victoria, South Australian Museum and Auckland Institute and Museum have also been examined, but the primary interest in these museums has been type material.

Descriptions are based on shells oriented in the traditional way, spire up, with the aperture facing the viewer. Synonymies are not complete; emphasis is given to systematic revisions, the historical literature, references to the species occurring in Australia, and an indication of the overall range of the species in Indo-Pacific localities. Australian ranges are given clockwise around the coast.

The following abbreviations are used: AIM, Auckland Institute and Museum; AMS, Australian Museum, Sydney; BM(NH), British Museum, Natural History, London; MNHN, Museum National d'Histoire Naturelle, Paris; MHNG, Museum d'Histoire Naturelle, Geneva; MV, Museum of Victoria, Melbourne; QM, Queensland Museum, Brisbane; SAM, South Australian Museum, Adelaide; SMNH, Swedish Museum of Natural History; TM, Tasmanian Museum, Hobart; WAM, Western Australian Museum, Perth; ZMB, Zoological Museum, Berlin; l, shell length; w, shell width; a, length of aperture.

Systematics

Species removed from *Inquisitor*

Hedley (1918) proposed the genus *Inquisitor* and later (Hedley, 1922) provided an extensive list of species, many of which are from the southeastern corner of Australia and which share a common shell morphology. Finlay (1924) considered *Drillia metcalfei* Angas, 1867 not to be an *Inquisitor*, but instead a member of the genus *Austrotoma*. Powell (1942) agreed that the species is not an *Inquisitor* but instead erected the genus *Vexitomina* for *D. metcalfei*. Laseron (1954) transferred several southeastern Australian *Inquisitor* to *Vexitomina*, proposals accepted by Powell (1969). These and other changes have substantially modified the genus *Inquisitor* from the original concept of Hedley (1922). The changes are summarized below:

Drillia metcalfei Angas, 1867 was transferred to *Vexitomina* as the type species of the genus by Powell (1942). Laseron (1954) expanded the genus to include seven

species from New South Wales, three of which had been included by Hedley (1922) in *Inquisitor*. These were: *Inquisitor coriorudis* Hedley, 1922; *Pleurotoma* (*Drillia*) *sauvis* Smith, 1888; and *Drillia coxi* Angas, 1867. All of these proposals were accepted by Iredale and McMichael (1962) and by Powell (1969), who revised the genus *Vexitomina* and incorporated several species from other genera.

Inquisitor plurinodulatus Cotton, 1947 (also cited by Cotton, 1959) is not an *Inquisitor*. The shell has spiral cords crossed by axial cords which give it a beaded appearance unlike *Inquisitor*. These structures also occur on shoulder, also in contrast to *Inquisitor*. The axial ribs are flattened, plate-like. The aperture is also too wide and rectangular. The species would be better placed in *Vexitomina* Powell, 1942.

Inquisitor sexradiatus Odhner, 1917 was also included in *Inquisitor* by Hedley (1922), Cotton (1947b) and Kosuge (1993). However examination of the holotype demonstrated its clavine shape, small size and few but strong axial ribs suggest this species should be placed in *Clavus*. It was not examined by Wells (1991a).

Drillia mastersi Brazier, 1876 was included in *Inquisitor* by Hedley, 1922 but has a lower spire, broader shell, and more rectangular aperture than *I. sterrhus*, the type of *Inquisitor*. The species is rejected from *Inquisitor*, but no recommendation is made of a proper placement for it.

Mangelia immaculata Tenison Woods, 1875 (1876) was transferred to a new genus, *Paracuneus*, as the genotype by Laseron, 1954 along with *Pleurotoma* (*Drillia*) *spadix* Watson, 1886. These proposals were also accepted by Powell (1969).

Inquisitor petilinus Hedley, 1922 was transferred to a monospecific genus, *Conticosta*, by Laseron (1954). Powell regarded *Conticosta* as a subgenus of *Inquisitor*. While no decision is made here on the validity of *Conticosta, C. petilinus* is not considered to be congeneric with *I. sterrhus*.

Mangilia crassicingulata Schepman, 1913 was recorded by Schepman from off Cape Jaubert, Western Australia, and included in *Inquisitor* by Hedley (1922). Powell (1966) also included the species in *Inquisitor*, but Shuto (1970) transferred it to *Pseudoetrema*. From the illustration provided by Schepman (1913: pl. 29, f. 1), the species is not an *Inquisitor*.

Inquisitor granobalteus Hedley, 1922 was considered to be a subspecies of *Turricula nelliae* (E. A. Smith, 1877) by Powell (1966; 1969), a determination agreed to by Wilson and Gillett (1979).

Inquisitor lacertosus Hedley, 1922 was transferred to *Micantapex* by Laseron (1954), which Powell (1966) regarded as a subgenus of *Bathytoma*. The species was included in *Clavus* by Wells (1991a).

Pleurotoma radula Hinds, 1843 is very close to *Vexitomina metcalfei* and was compared with it by Hedley (1922). As the species has not been recorded from New South Wales it was not discussed by Laseron (1954). The generic status of this species needs investigation. The type of this species is not in the BM(NH) type cabinet and could not be located in the general collection.

Pleurotoma (*Surgula*) *radulaeformis* Weinkauff, 1876 was not seen by Hedley (1922). Hedley remarked that the species is unknown to Australian malacologists, but suggested an apparent resemblance to *Vexitomina metcalfei*, the type of *Vexitomina* Laseron, 1954. Kilias (in. litt., 1992) believes the types of this species have been destroyed.

Inquisitor spurius was a name introduced by Hedley, 1922 for *Pleurotoma tayloriana* Reeve, 1846. Powell (1966; 1969) regards this as a subspecies of *Turricula nelliae* (E. A. Smith, 1877).

Pleurotoma (*Drillia*) *multilirata* Smith, 1877 was included in *Inquisitor* by Hedley, 1922. Laseron (1954) pointed out correctly that whatever its proper classification is, the species is not an *Inquisitor*. Laseron also considered that the species does not occur in New South Wales, even though the type locality is Port Jackson. The type in the BM(NH) (1860.5.31.42) has a locality of Port Jackson?, suggesting that the locality may be in error. The specimen figured by Hedley (1922) from 300 fathoms off Sydney was actually the type. There is thus no confirmed Australian record of the species.

Pleurotoma laterculata Sowerby, 1870 was recorded by Hedley (1922) in the genus *Inquisitor* based on specimens recorded from Queensland by Smith (1884) and Watson (1886). However, these specimens are in the BM(NH) and are actually *Inquisitor flavidulus* Lamarck, 1804.

Genus *Inquisitor* Hedley, 1918

Type species: *Pleurotoma sterrha* Watson, 1881 by original designation.

Inquisitor: Hedley, 1918: M79. Hedley, 1922: 236–247. Powell, 1942: 93. Shuto, 1965: 168–172. Shuto, 1969: 195–198. Shuto, 1970: 163. Cotton, 1947a: 13–14; Cotton, 1947b: 7–10. Ludbrook, 1958: 87. Kilburn, 1988: 257–267. Taylor and Wells, in press.

Pseudoinquisitor Powell, 1942: 96. Shuto, 1965: 173. Powell, 1966: 79.

Diagnosis: Shells small to large, 13 to 57 mm, high spired, solid. Protoconch small, smooth, rounded, 2 whorls. Up to 12 flattened to convex teleoconch whorls. Suture thin, not channeled, may be undulating. Sculpture complex, dominated by axial ribbing which tends to start part way down whorl. Spiral cords of varying strength may be present, often including a strong subsutural cord. Outer lip thickened, often incurved. Sinus deep, U shaped. Callus absent. Columella narrow to medium width, smooth. Aperture deep. Anterior canal short, usually notched. Colour variable, off-white to colourful. Marginal plates of radula with short shaft with long cutting edge (Kilburn, 1989). Indo-Pacific; Recent and fossil at least to the Eocene, shallow water, primarily tropical.

Remarks: Shuto (1965) recognized both *Inquisitor* and *Pseudoinquisitor* at the generic level but Powell (1966: 79) concluded *Pseudoinquisitor* is in fact a synonym of *Inquisitor*.

The genus *Ptychobela* Thiele, 1925 has been considered by many authors to be a synonym of *Inquisitor*, but the late Virginia Orr Maes examined the radulae and considered the two genera to be separate, a view followed by Springsteen and Leobrera (1986) and Kilburn (1988). The question was investigated in detail by Kilburn (1989).

Powell (1944) listed 5 species of *Inquisitor* (as *Pseudoinquisitor*) from the Miocene of Victoria and Ludbrook (1958) recorded two species from South Australia.

As indicated above, the genus *Inquisitor* as recognized in this paper has been restricted from the concept of Hedley (1922). There is still considerable shell variation

between some of the species. However until the radulae become available for study and related genera are better understood, it seems best not to restrict the genus further.

Inquisitor sterrhus (Watson, 1881)

Plate 1, Figs. 1–4

Pleurotoma sterrha Watson, 1881: 426. Watson, 1886: 305, pl. 21, figs. 3a–c.

Pleurotoma torresiana Smith, 1884: 37, pl. 4, figs. D, D1. Melvill and Standen, 1899: 156.

Inquisitor sterrhus (Watson). Hedley, 1922: 246. Cotton, 1947b: 7. Rippingale and McMichael, 1961: pl. 17, fig. 10.

Drillia sinensis (not of Hinds). Brazier, 1876: 152.

Inquisitor formidabilis (not of Hedley). Rippingale and McMichael, 1961: pl. 17, fig. 11 (not fig. 10).

Shell: Shell large, 45 mm, heavy, narrow, very high spire. Protoconch high, smooth, rounded, 2 whorls, 0.42 mm high, 0.58 mm wide. Teleoconch up to 13 convex whorls. Suture impressed, slightly undulating. Whorls with broad, low axial ribs, which often line up on adjacent whorls, 14 on penultimate whorl, 16 on body whorl, extend to tip of shell. Ribs form 1/3 way down whorl, enlarge rapidly just above midwhorl and extend to next suture. Occasionally adjacent ribs fuse together and may form low varix. Numerous spiral cords, usually 7 on area between suture and upper edge of rib, third of which is largest. 8 prominent spiral cords on ribs of penultimate whorl, may be interspersed with fine spiral lirae. About 24 spiral cords on ribs and lower surface of body whorl. Numerous axial growth lines present. Outer lip thickened, margin crenulate, stromboid notch absent. Sinus on upper shoulder, deep U shaped. Aperture subrectangular, deep. Columella broad, flattened, umbilicate, slightly convex. Anterior canal of moderate length and depth, notched. Shell colourful; sutural area, both above and below sutures, has a yellowish band which extends over lower body whorl, centre of whorl white. Area between axial ribs moderate chocolate brown. Upper whorls orange brown, aperture similar.

Measurements:

	Length (mm)	Width (mm)	Aperture (mm)	W/L	A/L
sterrha					
syntypes	34.9	11.1	12.2	0.32	0.35
	26.9	9.3	9.3	0.35	0.35
torresiana					
syntypes	34.1	10.7	12.2	0.31	0.35
	21.2	7.4	8.4	0.35	0.40
Moreton Bay, Qld. (AIM)					
Mean (n=6)	38.0	13.4	13.3	0.36	0.36
S. D.	5.9	1.4	1.7	0.03	0.02
Range	31.1–45.7	11.5–15.1	11.1–15.3	0.33–0.40	0.33–0.38

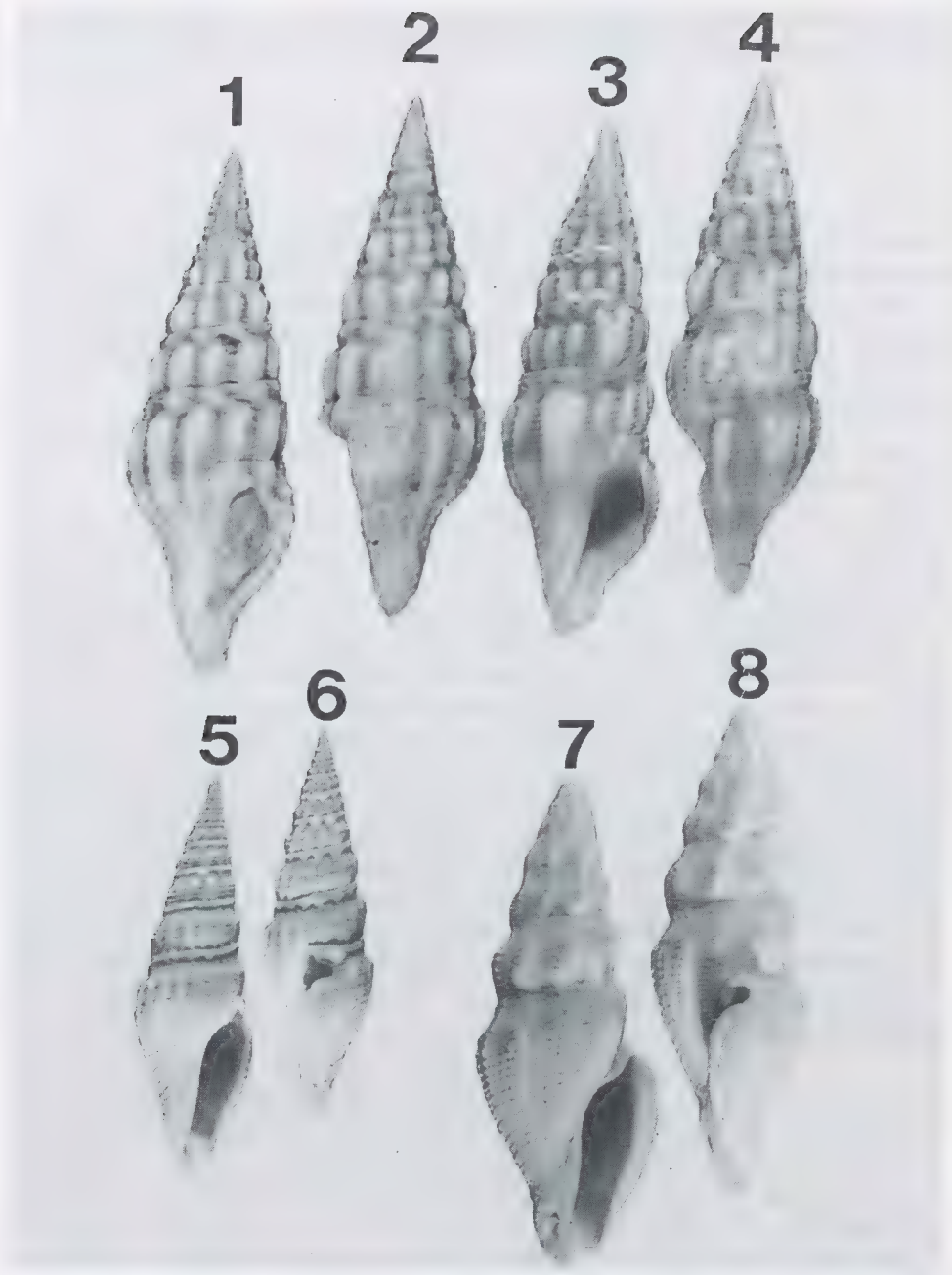

Plate 1. 1–4. *Inquisitor sterrhus* (Watson, 1881). 1–2. Syntype of *Pleurotoma sterrha*. BM(NH) 1887.2.9.995. 34.9 mm. 3–4. Syntype of *Pleurotoma torresiana* Smith, 1884. BM(NH) 1882.12.6.70. 34.1 mm. 5–6. *Inquisitor dampierius* (Hedley, 1922). Lectotype of *Melatoma dampieria*. AMS A.122. 21.5 mm. 7–8. *Inquisitor flindersianus* Hedley, 1922. Syntype of *I. flindersianus*. AMS C.14161. 31.8 mm.

Location of types: *sterrhus*: 2 syntypes, BM(NH) 1887.2.9.994 and 995. *torresiana*: 2 syntypes, BM(NH) 1882.12.6.70 and BM(NH) 1882.2.23.591

Type localities: *sterrhus*: 5–22 m, Cape York, Qld. *torresiana*: 13–16 m, Friday I., Gulf of Carpentaria, Qld. and Prince of Wales Channel, Torres Straits, Qld.

Material examined: Syntypes of both species. AUSTRALIA: QLD: Gulf of Carpentaria: 18 m, Mapoon (2 AMS; AIM); Karumba (AMS); 22 m, W of Nassua R. (AMS); Forsyth I., Wellesley Group (AMS); off Cape York Township (AMS); Torres Strait (2 AMS); low tide, Boigu I. (WAM); 46–55 m, Darnley I. (AMS); 9–15 m, Murray I. (AMS); 7–26 m, Albany Passage (2 AMS; AIM); Princess Charlotte Bay (AMS); 34 m, 11 m, 13°12'S; 143°34'E (AMS); 18 m, 14°28'S; 144°55'E (AMS); N of N. Direction I. (AMS); 9–18 m, Hope I., SE of Cooktown (AMS); 16–22 m, Low Isles (AIM); Low Isles, near Port Denison (AMS); Buchan's Point, N of Cairns (AMS; 2 AIM); Michaelmas Cay, off Cairns (AMS); Armstrong's Beach, S of Innisfail (AMS); Townsville (4 AMS); Cape Pallendra, 10 km N of Townsville (AMS); Magnetic I., off Townsville (2 AMS); Ross River, Townsville (AMS); Lindeman I., Whitsunday Passage (2 AMS); 9 m, Bowen (AMS); Queen's Beach, Bowen (AMS); 31 m off Hayman I. (AMS); Yeppoon (2 AIM); north of Bustard Head, near Ethel Rocks (AIM); 70 m, NE of Gillett Cay, Swain Reefs (AMS); 54 m, off Herald Prong, Swain Reefs (AMS); NE Herald Cay (AMS); 10 m, Big Sandy Cay, Swain Reefs (AMS); 54 m off North-West I. (AMS); Keppel Bay (AIM); 45 m, Keppel Bay (AMS); Port Curtis (AMS); Rat I., Port Curtis (AIM; AMS); 16–22 m, Gatcombe Head, Port Curtis (AMS); 2–5.5 m, Quoin I.. Port Curtis (AMS); Gladstone Harbour (AMS; AIM); 15 m off Picnic Point, Hervey Bay (AMS); Dundowron Beach (2 AMS); 55 m, Tin Can Bay (AIM); Mooloolaba Beach (AMS); Moreton Bay: 12 m (AMS); Peel I. (3 AIM; AMS; WAM); off southwest Reef (AIM); 5–7 m off Dunwich (AIM; AMS); Sandgate (AIM); NW of Hanlon Light (AMS); 9 m off Woody I., Fraser I. (AMS). PNG: Hunuabada, near Port Moresby (AMS); W. end Manubada I., off Port Moresby (AMS). INDONESIA: 5–7 km W of Tg Lelat Trangan, Aru (6°46'S; 133°58'E) (WAM).

Distribution: Southern Papua New Guinea and Indonesia and from Yeppoon in the Gulf of Carpentaria and south along the Queensland coast to Moreton Bay.

Remarks: It is somewhat surprising that Smith (1884) described *Pleurotoma* (*Drillia*) *torresiana* as the shells are clearly conspecific with *Pleurotoma sterrha* described by Watson three years earlier. However Smith was apparently unaware of Watson's species and made no mention of it in his description of *P. (D.) torresiana*. There is no question that the two species are conspecific. They were both described from northern Queensland and have the same shell characteristics of size, general shape, number of whorls, sculpture, and colour.

Inquisitor dampierius (Hedley, 1922)

Plate 1, Figs. 5,6.

Melatoma dampieria Hedley, 1922: 250, pl. 45, fig. 41.

Antimelatoma dampieria (Hedley). Cotton, 1947b: 7.

Splendrillia dampieri (sic). Wells and Bryce, 1986: 120, pl. 40, f. 464.

Shell: Shell of moderate size, 41 mm, heavy, narrow, high spire. Protoconch small, smooth, 2 whorls, upper whorl rounded, lower with straight sides, 0.48 mm high, 0.66 mm wide. Up to 12 teleoconch whorls. Suture thin, crenulated. Sculpture very complex, dominated by strong, narrow axial ribs, 16 on penultimate whorl, 15 on body whorl. Ribs on body whorl variable, some extend well below shoulder but others end and are replaced by small ribs offset to each side, do not reach anterior tip of shell, begin 1/3 of the way down the whorl where they are largest, decrease but reach lower suture. Very strong, rounded subsutural spiral cord followed by up to 5 low spiral cords before ribs. About 8 pronounced, rounded spiral cords on ribs of each whorl, 27 on body whorl which extend to anterior tip. Small varices formed at irregular intervals on spire. Numerous axial growth lines. Outer lip extends beyond varix, slightly thickened and slightly incurved, indistinct stromboid notch, margin crenulated by spiral cords. Sinus subsutural, deep V shape. Callus strong, dome shaped. Columella thin, smooth, slightly convex. Aperture elongate, deep, narrow. Anterior canal short, narrow, deep, anterior end notched. Colour uniform orange to dark brown, aperture similar.

Measurements:

	Length (mm)	Width (mm)	Aperture (mm)	W/L	A/L
Lectotype					
Paralectotype Broome (AIM)	21.5	7.5	8.4	0.35	0.39
Mean (n=14)	31.2	10.1	10.8	0.33	0.35
S.D.	3.8	1.0	1.3	0.02	0.02
Range	26.5–40.8	9.0–12.1	9.2–13.8	0.30–0.35	0.31–0.36

Location of types: Lectotype AMS A.122. 2 paralectotypes, AMS A.122.

Type locality: Shark Bay, W. A.

Material examined: AUSTRALIA: WA: Shark Bay (Paralectotype); Shark Bay (Lectotype); Shark Bay (Paratype); Shark Bay (WAM); Useless Loop, Shark Bay (WAM); South Passage, Shark Bay (2 WAM); 7 km NE Cape Peron, Shark Bay (WAM); W side Heirrisson Prong, Shark Bay (26°03'S; 113°20'E) (WAM); ENE Castle Point, Dorre I., Shark Bay (25°28'S; 113°08'E (WAM); near Denham, Shark Bay (AMS); Exmouth Gulf (3 WAM); between Bundegi Reef and Exmouth Homestead (AMS); SE of Exmouth Homestead (AMS); 17 miles south of Exmouth (AMS); Giralia Bay, Exmouth Gulf (WAM); Sandalwood Point, Exmouth Gulf (WAM); E side Pascoe I. (20°58'S; 115°20'E)(WAM); Hooley Creek, Onslow (WAM); Onslow (WAM); Off Long I. off Onslow (WAM); 12 km off Long I. off Onslow (WAM); Roebuck Bay, Broome (AMS); Broome (3 AMS; 7 AIM; WAM). NT: Darwin (WAM).

Distribution: Shark Bay, Western Australia to Broome, Northern Territory.

Remarks: *Inquisitor dampierius* is similar to *I. spaldingi* (Brazier, 1876), but is much larger (up to 40 mm versus 15 mm), darker in colour, with stronger axial ribbing and a larger protoconch. *Inquisitor dampierius* is similar in size to *I. flindersianus* Hedley, 1922 from which it may be separated by having a larger protoconch, darker

colour, more numerous (16 vs. 12) but smaller axial ribs, more prominent subsutural cord, and the outer lip not reflected inwards. *Inquisitor dampierius* can be separated from *I. spaldingi* Brazier, 1876 by being larger (up to 40 mm vs. 21 mm), with weaker spiral cords, and the outer lip not reflected inwards.

Inquisitor flindersianus Hedley, 1922

Plate 1, Figs. 7,8.

Pleurotoma alabaster var. Brazier, 1876: 154 (not *P. alabaster* Reeve).

Inquisitor flindersianus Hedley, 1922: 239, pl. 44, fig. 28. Cotton, 1947b: 7.

Shell: Shell small for genus, 25 mm, broad, high spire, solid. Protoconch rounded, smooth, 2 whorls, 0.54 mm high, 0.68 mm wide. Teleoconch up to 9 convex whorls. Suture thin, straight, distinct. Sculpture of strong axial ribs which begin at upper suture, reach maximum midwhorl, taper off, but reach lower suture, 12 on penultimate whorl, 14 on body whorl. Final rib of body whorl swollen into varix. Ribs extend well down body whorl but not to tip. Strong subsutural, knobby spiral cord followed by several spiral lirae. 7 spiral cords cross ribs of penultimate whorl, about 25 extend over entire surface of body whorl from upper ribs to anterior end of shell. Numerous microscopic lirae cross spiral cords. Outer lip slightly thickened, crenulate. Sinus deep, U shaped but narrowly constricted by strong callus, at 45° angle to shell. Columella thin, smooth, slightly convex. Aperture deep, elongate-ovate. Anterior canal short, broad, shallow, slightly notched. Colour light orange, nodules formed where cords cross ribs are white on shoulder as are some down the body whorl. Protoconch orange, aperture white.

Measurements:

	Length (mm)	Width (mm)	Aperture (mm)	W/L	A/L
Syntypes					
AMS C.14161	31.8	11.8	13.8	0.37	0.43
	25.9	10.0	10.8	0.39	0.42
AMS C.7575	28.3	10.3	11.4	0.36	0.40
AMS C.43724	29.4	10.7	12.8	0.36	0.44
Albany Passage, Torres Strait, Qld. (AMS C.55676 &7)					
Mean (n=7)	22.1	8.4	9.5	0.38	0.43
S. D.	5.2	1.3	1.8	0.04	0.03
Range	17.3–30.8	7.1–10.3	7.8–12.4	0.33–0.43	0.40–0.48

Location of types: Syntypes, 2 specimens. AMS C.14161. 1 specimen. AMS C.7575. 1 specimen, AMS C.43724.

Type locality: 18 m, Mapoon, Queensland (AMS C.14161); 55 m, Darnley I., Torres Strait, Qld. (9°35'S; 143°46'E) (AMS C.7575); 9–15 m, off Murray I., Torres Strait, Qld. (9°56'S; 144°04'E)(AMS C.43724); 7–26 m, Albany Passage, Cape York Peninsula, Qld. (10°45'S; 142°37'E) (AMS 42728).

Material examined AUSTRALIA: NT: Darwin (AMS); 51 m depth, Clarence Straits, south of Bathurst I., N.T. (12°01'S; 130°08'E) Muriel King Memorial Expedition Stn. B1/2&3. QLD: Van Diemans Inlet (2 AMS); 18 m, Mapoon (AMS); Torres Strait: Darnley I. (AMS); off Murray I. (AMS); Albany Passage (2 AMS); 5–11 m, Peak Point,(AMS); 16–22 m, Low I., off Port Douglas (2 AMS); Lucinda (AMS); 0–45 m, off Townsville (3 AMS); Magnetic I. (AMS); 27 m, Whitsunday Passage (AMS); Yeppoon (2 AMS); Keppel Bay (2 AMS); Rat I., Port Curtis, Gladstone (AMS); Port Curtis (2 AMS); 15–24 m, Gladstone Harbour (2 AMS); 18 m, Round Hill (AMS); 18 m, Tin Can Bay (AMS); 5–7 m, off Dunwich, North Stradbroke I. (AMS).

Distribution: Western Pacific; Darwin, Northern Territory to Stradbroke I., Queensland.

Remarks: *Inquisitor flindersianus* is similar to *I. spicata* in its small size, north Queensland distribution, numerous axial striations, the shape of the aperture, deep sinus and 45° angle to the shell, but *I. flindersianus* can be easily separated by being larger, heavier, orange in colour, lacking granulations below the suture and having a wider body whorl with weaker spiral sculpture.

Inquisitor spicata (Hinds, 1843)

Plate 2, Figs. 1–8.

Clavatula spicata Hinds, 1843: 39. Hinds, 1844: 17, pl. 5, fig. 11.

Drillia spaldingi Brazier, 1876: 153. Hedley, 1922: 245. Cotton, 1947b: 7.

Inquisitor fibratus Hedley, 1922: 238, pl. 43, fig. 27. Cotton, 1947b: 7.

Drillia hololeuca Odhner, 1917: 58, pl. 2, fig. 61.

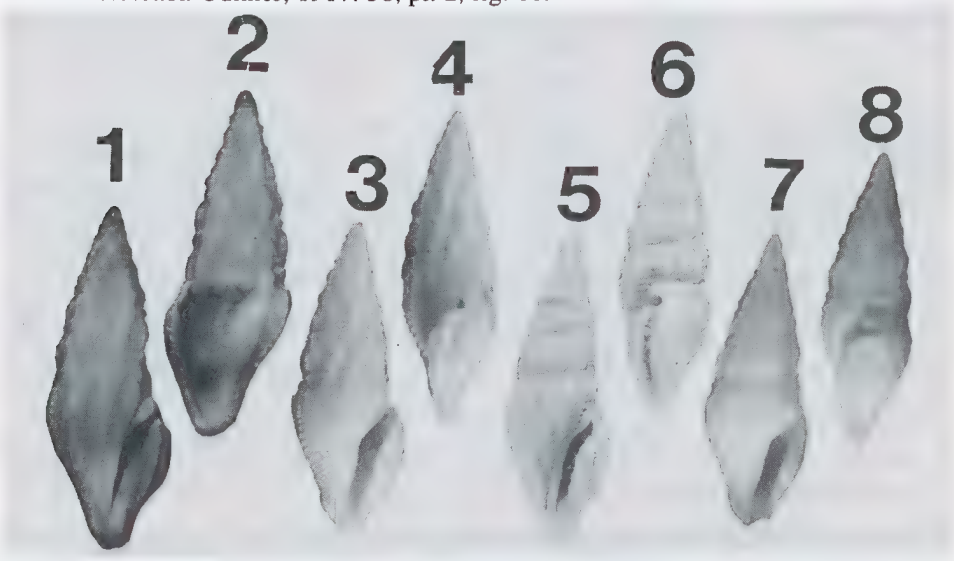

Plate 2. 1–8. *Inquisitor spicata* (Hinds, 1843). 1–2. Holotype of *Clavatula spicata*. BM(NH) 1879.2.26.52. 9.8 mm. 3–4. Syntype of *I. spaldingi*. AMS A.98. 13.5 mm. 5–6. Holotype of *I. fibratus* Hedley, 1922. AMS C.43728. 14.6 mm. 7–8. Holotype of *Drillia hololeuca* Odhner, 1917. SMNH 1075. 17.2 mm.

Inquisitor hololeuca (Odhner). Hedley, 1922: 241. Cotton, 1947b: 7.

Shell: Shell small for genus, 21 mm, narrow, very high spire, solid. Protoconch low, smooth, dome shaped, of 2 whorls, 0.32 mm high, 0.50 mm wide. Up to 9 teleoconch whorls. Suture narrow, slightly undulating, channeled, with granulose lower margin. Strong, narrow axial ribs begin at upper suture, thin out but re-emerge rapidly and reach maximum at midwhorl, extend to lower suture, 11 on penultimate whorl, 13 on body whorl. Final rib of body whorl swollen into a varix; no varices on upper whorls. Ribs extend nearly to tip of body whorl. Numerous low, rounded spiral cords, one large cord subsuturally followed by about 3 axial striae. About 8 spiral cords on ribs of penultimate whorl may be interspersed with lirae. About 27 spiral cords on ribs and lower part of body whorl, extend to tip of shell, may be interspersed with lirae. Large numbers of microscopic axial striae between cords over entire surface of shell. Aperture deep, elongate, subrectangular. Outer lip thickened, shallow, indistinct stromboid notch. Deep U shaped sinus on upper shoulder with pronounced callus causing sinus to be at 45° angle to shell. Columella narrow, smooth. Shell truncate, anterior canal short, shallow, broad, slightly notched. Known only from dead collected material which is uniform off-white colour.

Measurements:

	Length (mm)	Width (mm)	Aperture (mm)	W/L	A/L
spicata					
Holotype	9.8	1.6	—		
spaldingi					
Figured syntype	13.5	5.1	5.1	0.38	0.38
Other syntypes					
Mean (n=7)	14.0	5.1	5.4	0.36	0.38
S. D.	1.4	0.6	0.6	0.01	0.02
Range	12.3–16.0	4.5–5.9	4.6–6.3	0.35–0.38	0.35–0.41
fibratus					
Holotype	14.6	5.3	5.3	0.36	0.36
Paratype (AIM)	15.2	5.2	5.3	0.34	0.35
Paratypes (AMS)					
Mean (n=6)	15.7	5.3	5.4	0.34	0.34
S. D.	0.7	0.2	0.3	0.02	0.02
Range	14.5–16.4	5.0–5.5	5.1–5.8	0.31–0.37	0.32–0.37
hololeuca					
Holotype	17.2	5.9	6.2	0.34	0.36
Other specimens					
Yeppoon, Qld. (AIM)					
Mean (n=5)	17.1	5.7	5.7	0.33	0.33
S. D.	3.2	1.1	1.0	0.01	0.01
Range	12.3–20.9	4.2–6.7	4.2–6.7	0.32–0.35	0.32–0.35

Operculum: Not known.

Location of types: *spicata*: Holotype, BM(NH) 1879.2.26.52. *spaldingi*: Syntype, 1 specimen. AMS A.98. *fibratus*: Holotype, AMS C.43728. 10 paratypes, AMS C.43728 and 1 paratype, AIM 49128. *hololeuca*: Holotype, SMNH No. 1075.

Type localities: *spicata* Bow Island. *spaldingi*: 20 m, Bet Island, Torres Strait, Queensland. *fibratus*: 7–26 m, Albany Passage, Torres Strait, Queensland. *hololeuca*: 72 km WSW Cape Jaubert, Western Australia.

Material examined: Types. QLD: Van Diemen's Inlet, Gulf of Carpentaria (AMS); Mapoon, (AMS); Torres Strait: Albany Passage (AMS); 4 m, off Yeppoon (AMS); Facing Island, N of Gladstone (AMS); 4 m, Gladstone Harbour (AMS); Barney Point, Port Curtis, Gladstone (AMS), Bowen (AMS); 2–5.5 m, Quoin I., Port Curtis (AMS); Bowen (AMS).

Distribution: From Cape Jaubert, Western Australia to Bowen, Queensland. The holotype of *P. hololeuca* is the only Western Australian record of this species.

Remarks: This species is easily recognized primarily by the granulated lower edge of the suture, and also by its small size and fine axial lirae. It has been redescribed several times. The holotype of *I. spicata* is smaller than the other type material, but the shell characters are similar.

The holotype of *Inquisitor fibratus* is similar in size to the figured syntype of *I. spaldingi* (Brazier, 1876) but differs in having a broader shell, weaker axial ribs and spiral cords, suggesting that the two are separate species. However, the figured specimen is quite worn. There is a full range of broader shells among the other syntypes, and the more freshly dead specimens of *I. spaldingi* have the stronger sculpturing of *I. fibratus*. Both species were described from the shallow waters of Torres Strait, and it is concluded they are conspecific.

Powell (1966) believes *Drillia hololeuca* to be very close to *I. fibratus* which was described much later, and considered that at best it would be a subspecies. The holotype of *D. hololeuca* fits clearly within the range of variation seen within *I. spaldingi* in terms of its length and other shell measurements. The only major difference is that the lower edge of the suture is not as granulated as in eastern specimens. While *D. hololeuca* was described from Western Australia, and is still the only W. A. record, this difference does not warrant subspecific recognition.

Inquisitor lassulus Hedley, 1922

Plate 3, Figs. 1–4.

Inquisitor lassulus Hedley, 1922: 242, pl. 44, fig. 33. Cotton, 1947b: 7.

Brachytoma alma Thiele, 1930: 585, pl. 4, f. 62.

Shell: Shell small for genus, 21 mm, narrow, biconic, very high spire, solid. Protoconch high, conical, rounded at end, smooth, 3 whorls, 0.54 mm high, 0.64 mm wide. Up to 9 teleoconch whorls. Suture narrow, slightly undulating, indistinct. Sculpture complex, dominated by strong but narrow axial ribs which begin 1/3 way

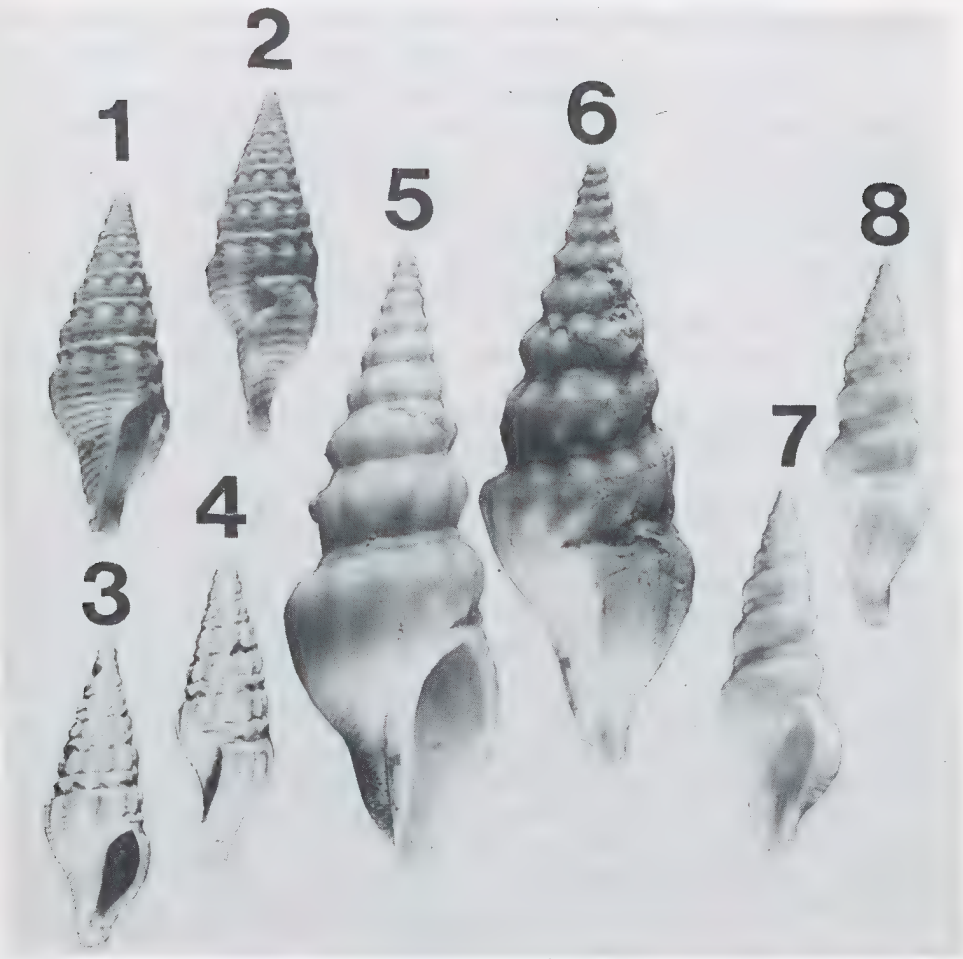

Plate 3. 1–4. *Inquisitor lassulus* Hedley, 1922. 1–2. Holotype of *I. lassulus*. AMS C.29734. 14.0 mm. 3–4. Holotype of *Brachytoma alma* Thiele, 1930. ZMB 67579. 11.8 mm. *Inquisitor kilburni* n.sp. 5–6. Holotype of *I. kilburni*. WAM 92–92. 31.6 mm. 7–8. *Inquisitor hedleyi* (Verco, 1909). Syntype of *Drillia hedleyi*. AMS C.31071. 18.5 mm.

down whorl, extend to lower suture. Ribs rapidly peak then decrease down whorl, 11 on penultimate whorl, 12 on body whorl, extend well down body whorl. Final rib of body whorl swollen into a varix, additional varices at about 1 whorl intervals on spire. Strong sculpturing of low, flattened spiral cords. Largest is subsutural, undulating, 5 additional ones on penultimate whorl, 20 on body whorl, extend to tip of shell. Numerous axial striae between cords. Outer lip extends well beyond varix, thin, distinct stromboid notch. Sinus on upper shoulder very deep, U shaped, constricted at entrance by strong callus, at 60° angle to shell. Columella very thin, slightly convex, smooth. Aperture deep, elongate. Anterior canal long, narrow, partially covered by columella, tip notched. Colour glossy white with orange tint between ribs, bright orange on subsutural cord. Protoconch and aperture glossy white.

Measurements:

	Length (mm)	Width (mm)	Aperture (mm)	A/L	W/L
Holotype (*lassulus*)	14.0	4.7	5.4	0.34	0.39
Paratype (*lassulus*)	12.5	4.5	4.5	0.36	0.36
Holotype (*alma*)	11.8	4.2	4.3	0.36	0.36
33 m, west of Hayman I., Qld. (AMS)					
Mean (n=7)	16.1	5.5	5.8	0.34	0.37
S. D.	2.7	0.6	0.6	0.03	0.04
Range	12.6–20.3	4.9–6.4	5.0–6.8	0.31–0.38	0.33–0.45

Location of types: *lassulus*: Holotype, and one paratype, AMS C.29734. *alma*: Holotype, ZMB 67579.

Type locality: *lassulus*: 15 m, Weary Bay, Queensland. *alma*: Shark Bay, Western Australia.

Material examined: Types. AUSTRALIA: WA: SE Exmouth Homestead, S. of Learmonth (AMS); 84 m, 12 km NNW Anchor I., off Onslow (WAM); 51 m, 12 km N of Long I., off Onslow (WAM); 77 m, 14 km N of Long I., off Onslow (WAM); 42 m, 32 km N of Delambre I., Dampier Archipelago (WAM); 36–37 m, 96 km NNE Port Hedland 19°30.9–28.2'S; 118°49.2–55.4'E (AMS). 112 m, 157 km NNW Port Hedland (19°08.8'S; 118°01.3'E (3 AMS); 110 m, 133 km NNW Dampier (19°28.9–29.0'S; 116°29.4–0'E (3 AMS); 82 m, 144 km NNE Port Hedland (19°04, 4–2'S; 119°04.4–00'E (AMS); NT: 27–37 m, off Point Charles (AMS). QLD: 28 m, S. of Sweers I., Gulf of Carpentaria (AMS); Hospital Point, Thursday I., Torres Strait (AMS); 46–55 m, Darnley I., Torres Strait (2 AMS); 37 m, between Cairns and Endeavour Reefs (2 AIM; 2 AMS); 16–22 m, Low Isles, off Port Douglas (AIM; 8 AMS); Buchan's Point between Cairns and Port Douglas (2 AIM); 40–37 m, off Cairns (16°55'S; 146°07'E) (AMS); 33–35 m, off Cairns (16°51'36–00'S; 146°01'12"–04'E) (AMS); 64 m, 11°50'S; 143°34.2'E (AMS); 24 m, 12°9.0'S; 143°13.2'E (AMS); 22 m, 13°28.2'S; 143°42'E (2 AMS); 15 m, 14°25.1'S; 144°48.6'E (AMS); 12–14 m, Deacpolis Reef, Cape Flattery 14°50'S; 145°17'E (AMS); 18 m, 15°39.3'S; 145°22'E (AMS); 21 m, 15°42.9'S; 145°25.6'E (AMS); 29 m, 15°45.6'S; 145°35'E (AMS); 8–9.5 m, off Townsville (AMS); 27 m, Palm I., N of Townsville (2 AMS); 27 m, Whitsunday Passage (AMS); 36–45 m, off Bowen (AMS); 33 m, W of Hayman I. 20°03'S; 148°50'E (AMS); 42 m, E of Sarina 21°27.5'S; 150°08'E (2 AMS); 64–73 m, 3 km NE west side Gillett Cay, Swains Reef (AMS); 187 m, SE of Swain's Reef 22°26.27–20.2'S; 153°17.13–6'E (AMS); 75–80 m, off Moreton Bay 27°31'S; 153°40'E (2 AMS); 183 m, NNE Cape Moreton (AMS).

OTHER AREAS: 22–33 m, SW of Yule I., PNG (AMS); 29–30 m, Sunda Strait, Java Sea, Indonesia (2 AIM); 42 m, Java Sea, Indonesia 6°42'S; 105°17'E (AIM); 200 m, Java Sea, Indonesia (7°33'S; 5°36'E (AIM); 34–37 m, between Du Rowa and Kai Dulah, Kai, Indonesia (5°32'S; 132°46'E) (2 WAM); 60–66 m, 13 km SW of Tg Ratoe, Maikoor, Aru, Indonesia (6°07'S; 133°57'E) (WAM); 55 m, Mussadem (AIM); 64 m, Persian Gulf (AIM); 37–64 m, Muscat (2 AIM).

Distribution: Indo-West Pacific; 22–200 m, Shark Bay, Western Australia to Moreton Bay, Queensland.

Remarks: *Inquisitor lassulus* is distinctive because of its small size, high spire, strong subsutural cord, colouration, and the 60° angle of the sinus. The colour of *I. lassulus* is variable, and the holotype selected by Hedley (1922) is simply a white form.

The type of *Inquisitor sinensis* should be in the BM(NH), but it is not in the type cupboard nor could it be located in the general collection. The locality given by Hinds is "New Guinea; Straits of Macassar; China Sea", very close to the Queensland type locality of *I. lassulus*. The figure provided by Reeve (1843) is similar to the holotype of *I. lassulus*, and it is possible the two are conspecific. However, in the absence of the holotype of *I. sinensis*, a conservative approach is adopted here and the name *I. sinensis* retained.

Powell (1966) compared *Brachytoma alma* Thiele, 1930 with *Splendrillia harpularia* (Desmoulins, 1842) and tentatively listed it as an *Inquisitor*. However, I have examined the type of *B. alma* from Shark Bay, Western Australia, and it is conspecific with the type of *I. lassulus* Hedley, 1922 from Weary Bay, Queensland. It is an eroded shell 14.0 mm long with the protoconch broken off, a chipped outer lip and a drill hole on the upper spire. All colouration has been lost. The shell has all the major characteristics of *I. lassulus*, including the rounded protoconch, heavy subsutural cord, and narrow ribs, 13 on the body whorl, and 11 on the penultimate whorl. The holotype of *B. alma* is in the same size range as the types of *I. lassulus* and has similar shell measurements.

I. lassulus is easily distinguished from the other Australian *Inquisitor*, but closely resembles *Pleurotoma tuberosus* Smith, 1875 but has a heavier subsutural cord, narrower, more rounded protoconch, smaller and narrower ribs. In addition *I. tuberosus* is recorded only from Japan.

Inquisitor kilburni n.sp.

Plate 3, Figs. 5–6.

Shell: Shell large for genus, 32 mm, heavy, high spire. Protoconch small, bulbous, 2 whorls, 0.63 mm high, 1.08 mm wide. 9 teleoconch whorls. Upper whorls triangular, lower convex, rounded. Suture thin, nearly straight, with indistinct spiral cord just below. Dominant sculpture of strong, broad axial ribs which begin 1/3 down whorl, reach largest at midwhorl, decrease but reach lower suture, 9 on body whorl, 11 on penultimate whorl, tend to line up on adjacent whorls. Outer portion of body whorl of holotype smooth, but repaired, and it is uncertain whether ribs would have occurred in this area; outer lip of paratype chipped back. Ribs reach well down body whorl but not to anterior tip. No varix formed. Fine spiral striae present on all whorls, begin at upper margin of axial ribs, 11 on penultimate whorl, about 25 on body whorl, extend to anterior tip of shell. Outer lip thin, rounded, stromboid notch small but distinct. Sinus of moderate depth, broad, U shaped, small, low, indistinct callus present. Columella thin, distinct, surface smooth, margin raised. Aperture deep, moderate width, elongate. Anterior canal short, broad, moderate depth, anterior margin indistinctly notched. Colour off-white, aperture glossy white.

Measurements:

	Length (mm)	Width (mm)	Aperture (mm)	W/L	A/L
Holotype	31.6	11.6	11.6	0.37	0.37
Paratype	29.6	10.7	11.7	0.36	0.40

Holotype: WAM 92–92. 146–150 m depth, W of Lancelin, W.A. (31°00'S; 114°52.5'E)

Paratypes: WAM 93–92(1). 131 m depth, W of Bluff Point, W.A. (27°40'S; 113°20'E). WAM 94–92(1). 128 m depth, NW of Bluff Point, W.A. (27°40'S; 113°03'E).

Material examined: Types.

Distribution: 131–150 m depth, Lancelin to Bluff Point, Western Australia

Remarks: *Inquisitor kilburni* is most similar to *I. formidabilis* Hedley, 1922 but can be distinguished by its smaller size (32 mm vs. 43 mm), more numerous axial ribs (11 vs. 9 on penultimate whorl), lack of an upturned flare on the anterior canal. In addition the surface of *I. formidabilis* is much rougher, with much more pronounced spiral cords.

Inquisitor kilburni is similar to *I. flindersianus* Hedley, 1922 but lacks the strong spiral striae and recurved outer lip.

Inquisitor kilburni also resembles *I. minutosternalis* in size, shape and general appearance, but can be readily distinguished by the lack of numerous spiral striae which are present on *I. minutosternalis*.

Etymology: I am pleased to name this species after Dr. Richard N. Kilburn of the Natal Museum, South Africa in recognition of the considerable work he has done in the field of turrid systematics and for his encouragement of my own research.

Inquisitor hedleyi (Verco, 1909)

Plate 3, Figs. 7,8.

Drillia hedleyi Verco, 1909: 302–303

Inquisitor hedleyi (Verco). Hedley, 1922: 241. Cotton, 1947b: 7. Cotton, 1959: 392.

Shell: Shell small, 13 mm, light, narrow, biconic, very high spire and elongate anterior canal. Protoconch small, high, conical 2 whorls, 0.42 mm high, 0.59 mm wide. 7 slightly angular teleoconch whorls. Suture straight, impressed. Whorls convex with strong, broad axial ribs, 11 on body whorl, 9 on penultimate whorl, angle to right, tend to match up on adjacent whorls. Ribs begin 1/3 way down whorl, enlarge rapidly, reach peak at midwhorl, decrease but reach lower suture, do not extend beyond shoulder of body whorl, ribs less distinct on body whorl. Final rib of body whorl swollen into varix. Upper surface of whorl with faint spiral striae. About 9 low, somewhat stronger spiral striae on penultimate whorl, about 35 on body whorl extend to anterior tip of shell. Final rib on body whorl enlarged into varix; thin, outer lip

extends beyond varix. Sinus deep, U shaped, entrance constricted by strong callus, points up at 45° angle. Columella very thin, nearly straight. Aperture deep, narrow, elongate. Anterior canal elongate, narrow, shallow, anterior tip rounded. Colour off-white, aperture semiglossy.

Measurements:

	Length (mm)	Width (mm)	Aperture (mm)	W/L	A/L
AMS syntype	18.5	4.6	7.7	0.25	0.41
BM(NH) paratype	19.1	5.9	7.7	0.31	0.40
SAM syntypes	14.4	4.4	5.6	0.31	0.39
	13.0	3.8	5.0	0.29	0.38

Location of types: Syntype, 1 specimen. AMS C.31071. 183 m off Beachport, S.A. (37°29'S; 140°00'E) Syntypes, 2 specimens. BM(NH) 1910.3.29.37–38. 201 m off Beachport, South Australia.

Syntypes, 2 specimens. D.15930. 366 m, off Beachport.

Material examined: Syntypes. SA: 183 m, 64 km S of Cape Wiles. 201 m off Beachport (SAM); 237 m off Beachport (SAM); 274 m off Beachport (SAM); 190 m off Stu I. (SAM); 190 m off Neptune I. (SAM); 165 m Cape Jaffa (SAM); 237 m Cape Jaffa (SAM).

Remarks: *Inquisitor hedleyi* is easily differentiated from the other Australian *Inquisitor* by being a narrower shell, with an elongated anterior canal, and markedly weaker axial and spiral sculpture.

Inquisitor glauce Dall, 1918

Plate 4, Figs. 1,2.

Pleurotoma (Drillia) ventricosus Smith, 1888: 301.

Drillia ventricosa Smith. Hedley, 1908: 487, pl. 10, f. 3. (not *Pleurotoma ventricosa* Deshayes, 1833).

Pleurotoma glauce Dall, 1918: 333. New name for *Pleurotoma (Drillia) ventricosa* Smith, 1888 (not *P. ventricosa* Deshayes, 1833, i.e. *P. ventricosa* Lamarck, 1804). *Inquisitor glauce* Dall. Hedley, 1922: 240. Cotton, 1947b: 7.

Shell: Shell medium, 27 mm, heavy, high spire. Protoconch small, low, rounded, smooth, 3 whorls, 0.66 mm high, 0.84 mm wide. 9 teleoconch whorls. Suture straight, impressed. Whorls convex with 13–15 low, broad axial ribs/whorl crossed by fine axial striae. About 17 small spiral cords on penultimate whorl, about 50 on body whorl. Axial ribs absent on upper part of whorl, begin at middle of whorl and extend to next suture; become low and fade out on lower part of body whorl. Final rib on body whorl enlarged into varix; thin, crenulated lip extends beyond varix. Small but distinct stromboid notch. Sinus deep, U shaped, entrance slightly constricted, points up at 45° angle. Inner surface of aperture thickened but does not form callus. Columella thin,

nearly straight, anterior canal broad, shallow. Aperture elongate, thin. Outer colour orangeish with spiral white streaks. Aperture orangeish internally, white at margins.

Measurements:

	Length (mm)	Width (mm)	Aperture (mm)	W/L	A/L
(*ventricosa*)					
Holotype	27.3	11.4	13.5	0.42	0.49

Location of type: (*ventricosa*) Holotype, 1 specimen. BM(NH) 1860.5.19.28.

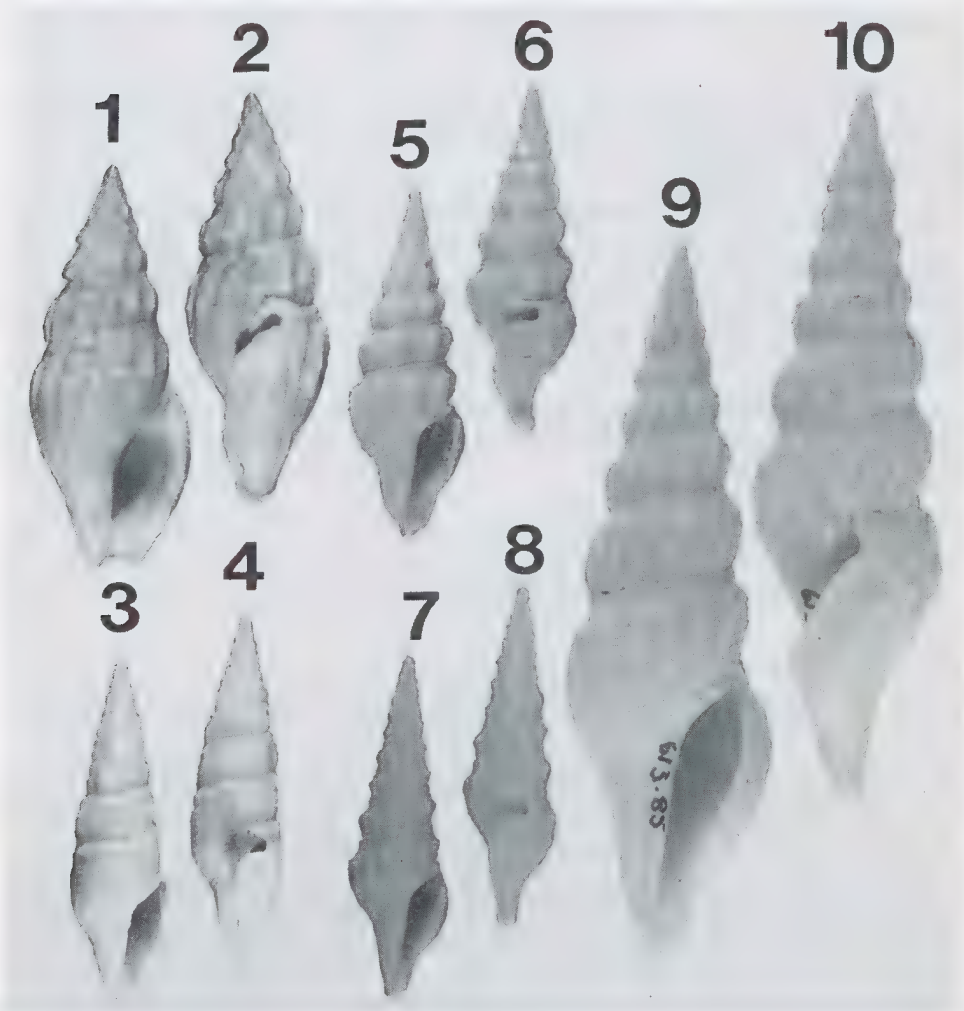

Plate 4. 1–2. *Inquisitor glauce* Dall, 1918. Holotype of *Pleurotoma* (*Drillia*) *ventricosa* Smith, 1888. BM(NH) 1860.5.19.28. 27.3 mm. 3–4. *Inquisitor odhneri* n.sp. Holotype of *I. odhneri*. WAM 85–92. 20.6 mm. 5–6. *Inquisitor minutosternalis* Kosuge, 1993. Holotype of *I. minutosternalis*. WAM 26–86. 25.4 mm. 7–8. *Inquisitor minimarus* Kosuge, 1993. Holotype of *I. minimarus*. WAM 12–86. 17.7 mm. 9–10. *Inquisitor angustus* Kuroda and Oyama, 1971. WAM 613–85. 47.5 mm.

Type locality: Between Percy I. and the mainland, Qld.

Material examined: Holotype

Remarks: *Inquisitor glauce* is closest to *I. sterrhus* but has smaller, broader ribs which are more vertical. The spiral cords of *I. sterrha* are larger with more lirae occurring between the ribs.

Inquisitor odhneri n. sp.

Plate 4, Figs. 3,4.

Shell: Shell small for genus, 23 mm, solid, very high spire. Protoconch small, high, smooth, 2 whorls, 0.74 mm high, 0.64 mm wide. 10 flat teleoconch whorls. Suture slightly channeled, straight. Sculpture complex with no single feature dominant. Pronounced spiral cord just below suture. Numerous axial lirae below cord give way to 22 axial ribs per whorl. Axial ribs low, narrow, crossed by five spiral cords on penultimate whorl. Ribs continue most of the way down body whorl but become very faint; about 20 spiral striae on body whorl. Beaded appearance where ribs and striae cross. Some ribs swollen into varices at intervals of about 0.5 whorls on upper whorls, 2/3 on lower whorl. Outer lip thin, slightly incurved. Sinus on shoulder deep, U shaped. Callus small but distinct. Aperture elongate, subrectangular. Columella thin, smooth. Shell truncate, anterior canal short, broad, deep. Shell and protoconch glossy white, varices yellowish. Aperture chalky white.

Measurements:

	Length (mm)	Width (mm)	Aperture (mm)	W/L	A/L
Holotype	20.6	6.3	6.9	0.31	0.34
Paratypes (WAM)	23.2	7.1	7.7	0.31	0.33
(AIM)	20.7	6.2	6.5	0.30	0.31
	20.1	6.5	6.5	0.32	0.32
(juvenile)	14.4	4.6	4.2	0.32	0.29
(AMS)	21.2	6.4	6.5	0.30	0.31
	20.9	6.1	6.3	0.29	0.30

Holotype: 42 m depth, 36 km N of Delambre I., Dampier Arch., W. A. WAM 85–92.

Paratypes: 42 m depth, 36 km N of Delambre I., Dampier Arch., W. A. (WAM 87–92(1) and WAM 88–92(2) and AIM(3 spec); 40 m, 11–13 km N of Delambre I., Dampier Arch., W. A. (WAM 84–92(1); 37–45 m, E of Monte Bello Is., W. A. (20°26'S; 116°00'E) (WAM 86–92(1); 50–52 m, 61 km N off Port Walcott, W. A. (19°59'S; 119°16'E)(WAM 91–92(1); 26 m depth, 22 km W of Eaglehawk I., Dampier Arch, W. A. (WAM 89–92(2) 42 m depth, NW of Little North I., Easter Group, Houtman Abrolhos, W. A. (WAM 90–92(1)

Distribution: 42 to 80 m depth, Houtman Abrolhos to Port Walcott, Western Australia.

Remarks: This species was referred to *Drillia varicosa* Reeve, 1843 by Odhner (1917), but Powell (unpubl.) regards it as being a separate species, differing from

Inquisitor varicosa in being constantly whitish with varices tinted yellow, the varices being wider apart, and there being more but weaker axial ribs. There are as many as 5 varices per whorl in *I. varicosa*, and the intermediate axials are fewer but stronger. In addition *I. varicosa* is a larger, heavier shell.

Inquisitor odhneri is similar to *I. minimarus* in size and shape, but can be readily distinguished by the lack of strong axial ribs, less angular whorl outline, broader shell, and the beaded appearance, which is lacking on *I. minimarus*.

Etymology: The late Dr. A. W. B. Powell recognized *I. odhneri* as a new species and included a preliminary description of it in a manuscript on the Indo-Pacific Clavinae intended for publication in Indo-Pacific Mollusca. Unfortunately the manuscript, and the new species, were never published. I have followed Dr. Powell's intentions and have named the species after Dr. Odhner.

Inquisitor minutosternalis Kosuge, 1993

Plate 4, Figs. 5,6.

Inquisitor minutosternalis Kosuge, 1993: 12, 13, pl. 5, figs. 3,4, text fig. 2.

Shell: Shell small for genus, up to 26 mm, solid, very high spire. Protoconch small, high, smooth, 2 whorls, 0.80 mm high, 1.05 mm wide. 10 strongly convex teleoconch whorls. Suture undulating, slightly channeled. Sculpture complex, dominated by strong, broad axial ribs, 9 on penultimate whorl, begin below spiral cord, rapidly expand, reach peak at about midwhorl, decrease but reach lower suture, 10 on body whorl, extend well beyond shoulder but not to anterior tip of shell. Pronounced spiral cord just below suture. Numerous strong axial striae below cord, about 8 on penultimate whorl, about 20 on body whorl. Occasional ribs swollen into varices. Outer lip thin, slightly incurved with distinct stromboid notch. Sinus subsutural, deep, margins callused, entrance slightly constricted by outer lip and strong subsutural callus. Aperture elongate, narrow, subrectangular. Columella narrow, smooth, margin strongly callused. Shell truncate, anterior canal short, broad, deep, anterior tip slightly raised. Shell colour uniform semiglossy off white, varices yellowish.

Measurements:

	Length (mm)	Width (mm)	Aperture (mm)	W/L	A/L
Holotype	25.4	8.8	9.3	0.35	0.37
Paratype lot (n=5)					
Mean	22.8	8.3	8.9	0.37	0.39
S.D.	2.5	0.5	0.7	0.02	0.02
Range	20.6–26.5	7.6–9.1	8.1–9.6	0.34–0.39	0.36–0.41

Type material: Holotype and 2 paratypes, WAM 26–86; an additional 12 specimens are in the lot.

Type locality: 200 m depth, 210 km N of Port Hedland, Western Australia (18°25'S; 118°22'E).

Other material examined: 156 m depth, 193 km NW of Port Hedland, Western Australia (19°06'S; 117°17'E).

Distribution: Known only from 156 to 200 m depth, N of Port Hedland, Western Australia.

Remarks: *Inquisitor minutosternalis* is closest to *I. kilburni* in size, shape and general appearance, but can be readily distinguished by the presence of numerous spiral striae which are absent on *I. kilburni*.

Inquisitor minimarus Kosuge, 1993

Plate 4, Figs. 7,8.

Inquisitor minimarus Kosuge, 1993: 11,12, pl. 5, figs. 1,2, text fig. 1.

Shell: Shell very small for genus, up to 18 mm, light, narrow, very high spire. Protoconch small, high, smooth, 2.5 whorls, 1.00 mm high, 1.05 mm wide, final whorl develops strong spiral keel at midwhorl. 9 strongly angular teleoconch whorls. Suture narrow, distinct, nearly straight, slightly channeled. Sculpture complex, dominated by strong, narrow axial ribs, 14 on penultimate whorl, begin below spiral cord, rapidly expand to reach distinct bimodal peak at midwhorl, decrease but reach lower suture, 13 on body whorl, extend well beyond shoulder but not to anterior tip of shell, penultimate rib swollen into strong varix. Pronounced spiral cord just below suture. Numerous strong axial striae below cord, 6 on penultimate whorl, about 21 on body whorl. Outer lip thin, strongly incurved with distinct, shallow stromboid notch. Sinus subsutural, at 45° angle to shell axis, very deep, margins callused, entrance slightly constricted by outer lip and strong subsutural callus, slight channel across surface of callus. Aperture elongate, narrow, subrectangular. Columella narrow, smooth, slightly convex, margin strongly callused. Shell truncate, anterior canal short, broad, deep, anterior tip slightly notched. Shell colour uniform semiglossy off white.

Measurements:

	Length (mm)	Width (mm)	Aperture (mm)	W/L	A/L
Holotype	17.7	5.4	6.4	0.31	0.36

Type material: Holotype, WAM 12–86.

Type locality: 154 m depth, 184 km NW of Port Hedland, Western Australia (18°47'S; 117°58'E).

Other material examined: 200 m depth, 210 km N of Port Hedland, Western Australia (18°25'S; 118°22'E).

Distribution: Known only from 154 to 200 m depth N pf Port Hedland, Western Australia.

Remarks: *Inquisitor minimarus* is closest to *I. odhneri* in size and shape, but can be readily distinguished by the presence of strong axial ribs, more angular whorl outline, narrower shell, and the lack of a beaded appearance found on *I. odhneri*.

Inquisitor angustus Kuroda and Oyama, 1971
Plate 4, Figs. 9,10.

Inquisitor angustus Kuroda and Oyama, 1971: 216, pl. 56, fig. 9, pl. 110, fig. 13. Kosuge, 1992: 169, 170, pl. 59, figs. 8,9, text fig. 1.

Shell: Shell large for genus, up to 58 mm, light, narrow, very high spire. Protoconch worn and eroded in Western Australian material. Up to 12 convex teleoconch whorls. Suture narrow, distinct, nearly straight, slightly channeled. Sculpture complex, dominated by strong, narrow axial ribs, 16 on penultimate whorl, begin below suture cord, rapidly expand to reach rounded peak at midwhorl, decrease but reach lower suture, 15 on body whorl, extend well beyond shoulder but not to anterior tip of shell, penultimate rib swollen into strong varix. Numerous strong axial striae below cord, 8 on penultimate whorl, about 24 on body whorl. Outer lip thin, strongly incurved with broad, indistinct, shallow stromboid notch. Sinus subsutural, at 45° angle to shell axis, very deep, moderate width, U shaped, margins callused, entrance slightly constricted by outer lip and strong low subsutural callus. Aperture elongate, narrow, subrectangular. Columella narrow, smooth, slightly convex, margin callused. Shell truncate, anterior canal short, narrow, deep, anterior tip slightly notched and raised. Shell colour indeterminate in Western Australian material, heavily eroded light gray.

Measurements:

	Length (mm)	Width (mm)	Aperture (mm)	W/L	A/L
WAM 613–85					
Mean (n=5)	52.8	13.5	19.1	0.26	0.36
S.D.	4.4	0.7	1.3	0.02	0.02
Range	47.5–58.3	12.5–14.2	17.3–20.7	0.24–0.29	0.34–0.40

Type material: Holotype presumably in Natural Science Museum, Tokyo.

Type locality: 70–80 m depth, Barane, Sagami Bay, Japan.

Material examined: 200 m depth, 210 km N of Port Hedland, Western Australia (18°25'S; 118°22'E).

Distribution: Japan to northwestern Australia.

Remarks: The Western Australian specimens of *Inquisitor angustus* were identified and figured by Kosuge (1992), and the identification is based on Kosuge's analysis. The material represents a considerable range extension from the type locality in Japan.

Inquisitor angustus is part of a suite of *Inquisitor* species that are very similar in appearance. Other species included in the group are *I. jeffreysi* (Smith, 1875) and *I. nudivaricosus* Kuroda and Oyama, 1971 and *Ptychobela flavidula* (Lamarck, 1816). The radula of *I. angustus* has not been figured, but when it is whether the species belongs in *Inquisitor* or *Ptychobela* will be clear. *Inquisitor angustus* is of the same size as the other three species but has a narrower shell, higher spire, and weaker axial ribbing.

Inquisitor formidabilis Hedley, 1922

Plate 5, Figs. 1,2.

Inquisitor formidabilis Hedley, 1922: 239, pl. 44, fig. 29. Cotton, 1947b: 7. Wilson and Gillett, 1979: 272, pl. 66, f. 12. Wells and Bryce, 1986: 120, pl.40, f. 465. Kosuge, 1992: 170–171, pl. 59, fig. 11.

Clavus formidabilis Short and Potter, 1987: 108, pl. 53, fig. 4.

Shell: Shell very large, to 57 mm, solid, very high spire. Protoconch small, high, conical, smooth, 2 whorls, 0.33 mm high, 0.36 mm wide. Up to 12 convex teleoconch whorls. Suture thin, undulating. Sculpture complex, dominated by up to 12 axial ribs per whorl. Small subsutural spiral cord on lower whorls of some specimens. Ribs develop about 1/4 of the way down the whorl, greatest just above midwhorl, taper rapidly and do not reach lower suture, extend well down body whorl. Numerous fine axial striae begin on spiral cord, angle to right and fade out, re-emerge on rib and angle to left, crossed by about 12 rounded spiral cords on penultimate whorl, giving shell a cross hatched appearance. About 24 spiral cords on body extend to base of shell, lower cords separated by a single spiral lirae. Final rib on body whorl swollen into a varix. Outer lip thin, incurved, with indistinct stromboid notch. Sinus subsutural, moderate depth, U shaped. Callus weak. Columella smooth, very thin. Aperture elongate-ovate. Anterior canal short, broad, shallow, strongly recurved, with shallow notch. Colour gray to light brown, aperture white, protoconch orangeish.

Measurements:

	Length (mm)	Width (mm)	Aperture (mm)	W/L	A/L
Syntypes	46.8	15.0	18.3	0.32	0.39
	42.9	14.9	15.2	0.35	0.35
Yeppoon, Qld. (AIM)					
Mean (n=11)	45.5	15.2	18.5	0.34	0.41
S. D.	6.7	1.7	2.7	0.01	0.01
Range	36.3–	13.2–	15.2–	0.32–	0.38–
	57.0	18.1	23.7	0.36	0.42

Location of types: Syntypes, 2 specimens. AMS C.14161.

Type locality: 18 m depth, off Mapoon, Gulf of Carpentaria, Qld.

Material examined: AUSTRALIA: NT: Gunn Point, E of Darwin (WAM); Port Keats (AMS); Groote Eylandt (AMS). QLD: Gulf of Carpentaria: 18 m, W of Edward River (AMS); Mapoon (2AMS; AIM); Townsville (AMS; AIM); Magnetic I., off Townsville (AIM); 37 m, off Bowen (AMS); headland between Kings and Queens Beaches, Port Denison (AMS); Gloucestor I. (AMS); St. Bees I. (AMS); Seaforth, Mackay (AMS); Yeppoon, (3 AMS; 2 AIM); Buchan's Point (AIM); Keppel Bay (2 AMS; 2 AIM); Long Beach, Keppel Bay (AMS); Gint I., Keppel Bay (WAM); Gladstone (2 AIM); Gladstone Harbour (AMS); Port Curtis, Gladstone (AMS); 5–7 m, North Stradbroke I. (AMS).

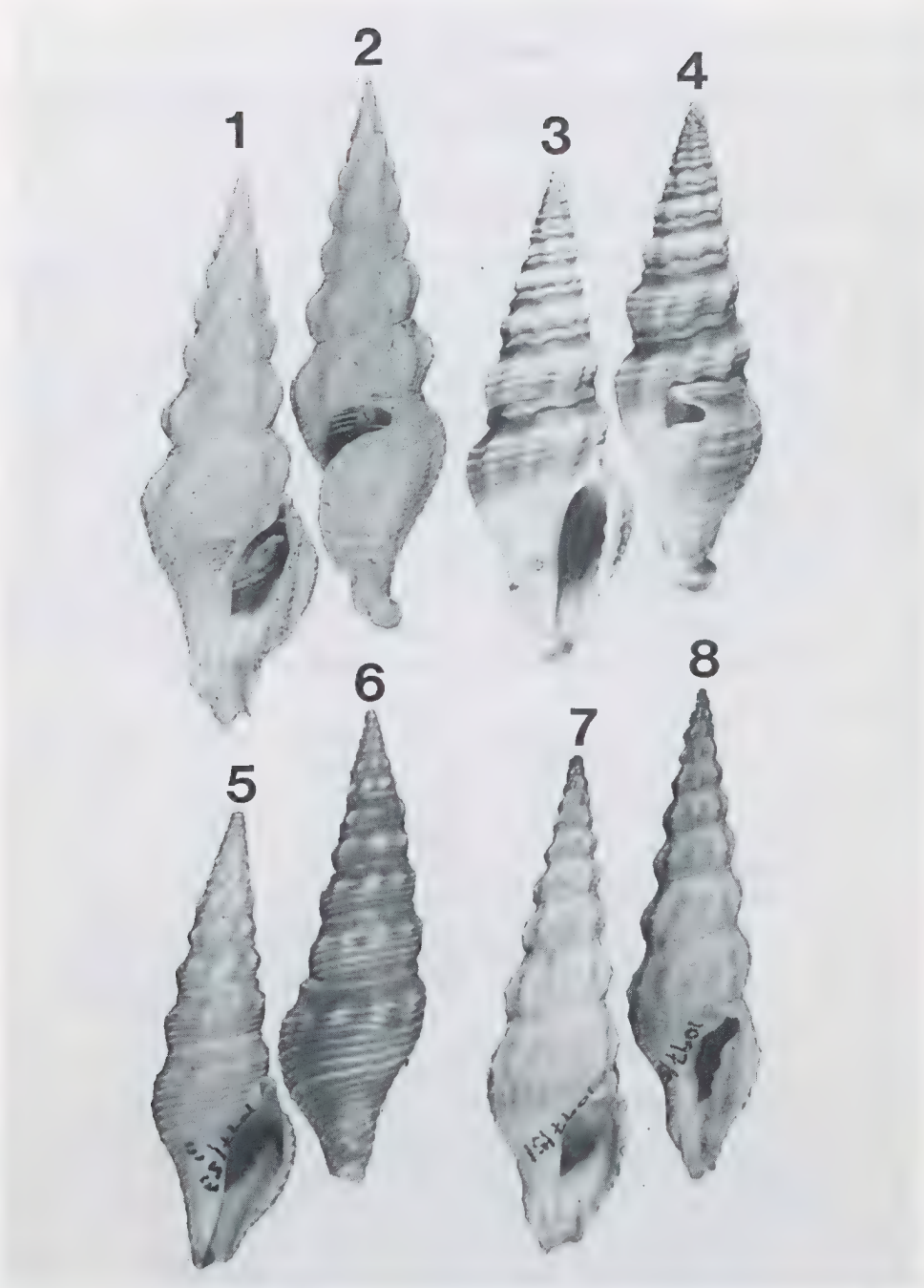

Plate 5. 1–2. *Inquisitor formidabilis* Hedley, 1922. Syntype of *I. formidabilis*. AMS C.14161. 46.8 mm. 3–6. *Ptychobela nodulosa* (Gmelin, 1791). 3–4. Neotype of *Murex nodulosus*. ANSP 231901. 43 mm. 5–6. Possible syntype of *Clavatula crenularis* Lamarck, 1816. MHNG. 40.0 mm. 7–8. *Ptychobela flavidula* (Lamarck, 1822). Holotype, MHNG 1097/51. 38.9 mm.

Distribution: 5–37 m, Gunn Point, east of Darwin, Northern Territory to Stradbroke, Queensland.

Remarks: *Inquisitor formidabilis* is closest to *Ptychobela flavidula* (Lamarck, 1816) but can be distinguished by having fewer but stronger axial ribs, crossed by weaker spiral cords, with the whorls more tightly wound. The basis for separating *Inquisitor* from *Ptychobela* is differences in the radula of the type species of the two genera (Springsteen and Leobrera, 1986; Kilburn, 1988; 1889). As the radula of *I. formidabilis* is unknown, it seems preferable to retain the species in *Inquisitor* until a radula becomes available.

Genus *Ptychobela* Thiele (1925)

Diagnosis: Shells medium to large, 45 to 57 mm, narrow, high spired, solid. Protoconch small, smooth, rounded, 2 whorls. Up to 12 flattened to convex teleoconch whorls. Suture thin, slightly channeled, straight or slightly undulating. Sculpture complex, dominated by axial ribbing which tends to start part way down whorl, 9–15 on penultimate whorl. Spiral cords of varying strength may be present, 4–7 on upper whorls, 15–20 on penultimate whorl, sometimes including a strong subsutural cord. Outer lip thickened, often incurved. Sinus subsutural, may be U shaped. Callus absent. Columella narrow to medium width, smooth. Aperture deep. Anterior canal moderately long, usually notched. Colour variable, off-white to colourful. Marginal plates of radula awl-shaped with sharp tip that lacks cutting edges (Kilburn, 1989). Indo-Pacific; shallow water, to at least 320 m, tropical.

Remarks: As mentioned above, *Ptychobela* was erected by Thiele (1925) with the type species being *Clavatula crenularis* Lamarck, 1816. Kilburn (1989) considers generic recognition of *Ptychobela* to be warranted because of differences in the radula from *Inquisitor*.

Ptychobela nodulosa (Gmelin, 1791)

Plate 5, Figs. 3–6.

Murex nodulosus Gmelin, 1791: 3562.

Clavatula crenularis Lamarck, 1816: pl. 440, f. 3 a,b.

Pleurotoma crenularis Lamarck, 1822: 92. Deshayes, 1843: 347. Reeve, 1843: pl. 7, sp. 54.

Drillia crenularis Pritchard and Gatliff, 1900: 172, doubted by Hedley 1922

Ptychobela crenularis (Lamarck). Thiele, 1925: 181, pl. 34, f. 29,31.

Brachytoma crenularis (Lamarck). Yen, 1942: 239.

Inquisitor crenularis (Lamarck). Powell, 1966: 239. Wilson and Gillett, 1979: 272, pl. 66, f. 11. Wells and Bryce, 1986: 120, pl. 40, f. 469.

Ptychobela nodulosa (Gmelin). Kilburn, 1989: 187–190, f. 1–4.

Shell: Shell of medium size, 45 mm, narrow, medium weight, very high spire. Protoconch smooth, glassy, rounded, 2 whorls, 0.40 mm high, 0.64 mm wide. 12 teleoconch whorls. Suture thin, slightly undulating. Nodulose axial ribs develop about halfway down whorl, low bulges, may or may not extend to lower suture, 10 on penultimate whorl, 9 on body whorl. Final rib on body whorl swollen into a varix which extends well down the shell. Other ribs restricted to shoulder. About 15 thin spiral cords on penultimate whorl, vary in size with large ones being subsutural and 4 at equal intervals beginning on upper rib. One major subsutural spiral cord on body whorl. 16 additional cords beginning at top of ribs and extending down entire whorl, some separated by spiral striae. Outer lip thin, slightly incurved, crenulated with distinct stromboid notch. Sinus subsutural, deep, U shaped at base, but broadens at top with upper flange with strong callus below. Columella thin, smooth. Aperture elongate-ovate, narrow, deep. Anterior canal narrow, deep, moderate length, anterior tip of shell notched. Shell glossy, background colour grayish-brown, darker between ribs, nodules and spiral cords white. Aperture whitish at opening, darker internally. Upper whorls and protoconch glossy brown.

Measurements:

	Length (mm)	Width (mm)	Aperture (mm)	W/L	A/L
possible syntypes	40.0	13.1	16.1	0.33	0.40
	36.7	13.1	16.1	0.36	0.44
	35.5	15.0	12.1	0.42	0.34
	30.6	12.9	14.0	0.42	0.46

Location of type: *nodulosa*: Neotype, ANSP 231901. *crenularis*: Possible syntypes, MHNG.

Type localities: Unknown.

Material examined: Type. AUSTRALIA: WA: 31 m, N of East Wallabi I., Wallabi Group, Houtman Abrolhos (WAM); 72 m, Dirk Hartog I., Shark Bay (WAM); Shark Bay (20°53'S; 115°22'E); SW of Point Cloates (22°43'S; 113°40'E) (2 WAM); W side Point Cloates (22°43'S; 113°40'E) (2 WAM); N end of bay N of Point Cloates (22°37'S; 113°38'E) (4 WAM); 14m, North side of Point Cloates (22°30'S; 113°42'E) (WAM); North West Cape (WAM); Bandicoot Bay, Barrow I. (20°52'S; 115°19'E) (WAM); 13 m, Thevenard I., off Onslow (WAM); 51 m, 11 km N of Long I., off Onslow (2 WAM); Onslow (WAM); Monte Bello Is. (AMS); Port Hedland (WAM; AMS); 90 mile Beach (AMS); Broome (8 AIM; 6 AMS; 4 WAM); Roebuck Bay, Broome (5 AMS); Cable Beach, Broome (AMS).

OTHER AREAS: Bali, Indonesia (AIM); Singapore (AIM); Ko Phuket, west coast of Malaysia (AIM); Quezon Prov., Philippines (AIM); Qarigara Bay, Sama, Philippines (AMS); southwest sea of Formosa (MHNG).

Distribution: Indo-West Pacific; Intertidal to 72 m, Houtman Abrolhos to Troughton Island, Western Australia.

Remarks: This is a variable species. The possible type series of *Clavatula crenularis* Lamarck, 1816 in the MHNG has four specimens, which are quite variable. All share the same general structure and shape, but the details differ significantly. Two of the four have very high, narrow spires (w/l ratios of 0.33 and 0.36), but the other two, which are also smaller, are relatively broader (0.42). On all four the axial ribs begin at or below midwhorl. On one possible syntype they do not extend to the lower whorl, but on three specimens they do. Colour of the four ranges from very light to dark gray; the ribs are noticeably lighter on the darker specimens.

Ptychobela nodulosa co-occurs with *Inquisitor dampierius* (Hedley, 1922) on the north coast of Western Australia. *Inquisitor dampierius* has a thinner shell, more numerous and stronger axial ribs which extend over more of the whorl, more numerous and stronger spiral striae, darker colour and a more beaded appearance.

Ptychobela flavidula (Lamarck, 1822)

Plate 5, Figs. 7,8.

Murex gibbosus Chemnitz, 1795 (in part)(nonbinom.): 113, pl. 190, figs. 1829, 1830.

Pleurotoma flavidula Lamarck, 1822: 92. Kiener, 1839–40: 30, pl. 6, fig. 2 and pl. 18, fig. 2. Reeve, 1843: pl. 8, fig. 66.

Drillia flavidula (Lamarck). Tryon, 1884: 177, pl. 10, fig. 56, 57.

Clavus (*Clathrodrillia*) *flavidulus* (Lamarck). Grant and Gale, 1931: pl. 26, fig. 4a, b.

Brachystoma flavidula (Lamarck). Yen, 1942: 238. Kira, 1964: pl. 36, fig. 10.

Clathrodrillia flavidula (Lamarck). Hinton, 1972: 60, pl. 30, f. 15.

Ptychobela flavidula (Lamarck). Springsteen and Leobrera, 1986: 268, pl. 76, f. 18.

Inquisitor flavidula (Lamarck). Kosuge, 1992: 170, pl. 59, f. 10.

Shell: Shell large, up to 56 mm, narrow, very high spire, solid. Protoconch small, smooth, conical, 2 whorls, 0.58 mm high, 0.68 mm wide. Up to 12 teleoconch whorls. Suture thin, indistinct, nearly straight, slightly channeled on lower whorls. Sculpture complex, dominated by low axial ribs, 15 on penultimate whorl, 13 on body whorl, angled to left. Final rib of body whorl swollen into a varix. Ribs begin about 1/4 way down the whorl, reach maximum above midwhorl, taper off but reach lower suture, extend well down body whorl, but not to tip. Ribs crossed by prominent series of triangular spiral cords, 7 on penultimate whorl, 15–20 on body whorl, smaller cords may be between larger ones. Numerous spiral striae occur over entire whorl surface. Low nodules occur where spiral cords cross axial ribs. Numerous fine axial growth lines also present. Outer lip thin, slightly incurved. Sinus subsutural, moderately deep, upper margin does not come forward. Moderately strong callus present. Aperture elongate-oval, relatively narrow, deep. Columella smooth, thin, slightly convex. Anterior canal moderately long, moderate width and depth, tip reflected upwards, slightly notched. Colour uniform light brown or yellowish with a single purple band across the body whorl (see description of holotype of *P. flavidula* below), nodules and aperture lighter.

Measurements:

	Length (mm)	Width (mm)	Aperture (mm)	W/L	A/L
flavidula					
holotype	38.9	11.3	13.3	0.29	0.34
146–184 m north of Caloundra, Qld. (AIM)					
	56.2	16.2	22.4	0.29	0.40
	54.8	16.6	22.2	0.30	0.41

Location of types: MHNG 1097/51.

Type localities: Red Sea.

Material examined: AUSTRALIA: WA: 42 m, off Little North I., Easter Group, Houtman Abrolhos (28°38'S; 113°54'E) (WAM); NW of Bluff Point (27°40'S; 113°20'E) (WAM); 128–131 m, W of Dirk Hartog I. (25°54'S; 112°38'E) (WAM); 128–130 m, W of Carnarvon (24°58'S; 112°30'S) (WAM); 95 m, 16 km N of Anchor I., off Onslow (WAM); 119 m, 16 km N of Anchor I., off Onslow (3 WAM); 119 m, 32 km NW of Anchor I. off Onslow (WAM); 13 m, Thevenard I., off Onslow (WAM); 200–202 m, 207 km NW of Port Hedland (19°04'S; 117°06'E) (WAM); 32 km N of Adele I. (WAM); 80 km NE of Adele I. (WAM); 92 m, 80 km ENE Troughton I. (WAM); 92 m, 208 km ENE Troughton I. (WAM); 344 km ENE Troughton I. (2 WAM). NT: 53–59 m, Clarence Straits, S of Bathurst I. (12°01'S; 130°08'E) (WAM); QLD: 284 m, E of North West I. (AMS); 210–229 m, E of Lady Musgrave I. (AMS); 128–183 m depth, off Caloundra (AIM); 132–155 m, off Mooloolaba (Maroochydore) (AMS).

OTHER AREAS: 128 m, NW of Tajandu I., Kai, Indonesia (5°30'S; 132°18'S) (2 WAM); 57–73, off W coast of Wasir I., W. Wokam, Aru, Indonesia (5°30'S; 134°12'E) (WAM); 46–51 m, W of Tg Derehi, Trangan, Aru, Indonesia (6°26'S; 133°57'E) (WAM); 73–92 m, off W coast of Wasir I., W. Wokam, Aru, Indonesia (5°30'S; 134°12'E) (WAM); 146 m, 5 km NW of Tg. tuwau, Selaru, Tanimbar, Indonesia (8°12'S; 130°49'E) (WAM); Rabaul, PNG (AMS); 37 m, Yule I., PNG (AMS).

Distribution: 18–320 m depth, Indo-West Pacific; Dirk Hartog Island, Western Australia to Moreton Bay, Queensland.

Remarks: *Inquisitor formidabilis* Hedley, 1922 is very close to *P. flavidula*, and the two are initially difficult to separate. *Inquisitor formidabilis* can be distinguished by having fewer but stronger axial ribs, crossed by weaker spiral cords, with the whorls more tightly wound. A 55 mm specimen of *P. flavidula* from off Cape Moreton, Queensland has for example 10 teleoconch whorls compared to 12 for a 52 mm specimen of *I. formidabilis* from off Yeppoon.

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The late Dr. A. W. B. Powell of the Auckland Institute and Museum was in the process of revising the Indo-Pacific Turridae before he retired. As I began to work on *Inquisitor* I was fortunate enough to see a draft manuscript of the Clavinae written by Dr. Powell, probably in the early 1960's. I have benefited from being able to compare my opinions with Powell's' but of course I am responsible for any errors I may have made.

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Book Review

Bieler, R. 1993. Architectonicidae of the Indo-Pacific (Mollusca: Gastropoda). Abhandlungen des Naturwissenschaftlichen Vereins in Hamburg (NF) 30: 1–376. 168 German marks (About $ 150 Australian).

The family Architectonicidae (the sundials) is unique among gastropods in having a combination of sinistral protoconchs and dextral teleoconchs. Until fairly recently architectonicids were classified as mesogastropods in the order Cerithioidea, but they have a combination of prosobranch and opisthobranch characteristics and do not fit into the traditional prosobranch, opisthobranch and pulmonate system of classification. Along with other families the architectonicids are now placed in a separate order.

The family is widespread in tropical and warm temperate seas. All species for which data are available have long distance planktonic larvae which allow them to occur over wide areas of the ocean such as from the east coast of Africa to the centre of the Pacific Ocean, with isolated individuals sometimes being recorded on the west coast of America. This wide distribution makes understanding of variations within a species difficult and tends to lead to a proliferation of names for species occurring in different areas. The animals prey on coelenterates.

The book reviewed here is the doctoral thesis of Dr. Rudiger Bieler, now of the Field Museum of Natural History in Chicago, Illinois, USA. It is presented as a monograph on the Architectonicidae. The monograph is a massive document based on an analysis of a substantial portion of all of the material available worldwide – over 22,000 specimens from 50 museum collections were studied. All available type material was examined.

The core of the book is a general section on sundials which outlines the shell and operculum, heterostrophy, anatomy and biology, zoogeography, and the fossil record. This is followed by an extensive systematic section which analyzes all of the 250+ species–groups names proposed for the family. Indo-Pacific species of the family are organized into 11 genera. Eighty-eight species are recognized, 20 of which are described as new. For each species there is a detailed account of the shell, including the protoconch, excellent black and white photographs, distribution maps, and information on anatomy, reproductive biology, larval development, ecology, and geographical distribution. There is also a limited number of colour photographs of shells and living animals.

The book is an unparalleled account of an interesting family. It is unfortunate that the cost will put it beyond the reach of most individuals.

Bieler's volume will be of considerable interest to Australasian readers. All eleven genera and nearly half (42) of the species occur in Australian waters. If the Western American species are disregarded the proportion of Indo-West Pacific species which live in Australia is even higher. Several of the new species are found in Australia and/or New Zealand. Despite the warmwater distribution of architectonicids eight of the genera and 14 species occur in New Zealand.

Dr. Bieler is to be congratulated on a very fine effort.

F. E. Wells

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General and theoretical papers relating to molluscs are welcome. Papers concerning specific geographical areas or new taxa should be restricted to the Indo-West Pacific region, as well as Australasia and the southern oceans. Papers received will be considered for publication at any time. Long papers and monographs may be published as special issues of *Molluscan Research*.

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Shepherd, S. A. and Cannon, J. 1988. Studies on southern Australian abalone (genus *Haliotis*). X. Food and feeding of juveniles. Journal of the Malacological Society of Australia 9: 21–26.

Kohn, A. J. and Amalsi, K. N. 1993. Comparative ecology of a biogeographically heterogeneous *Conus* assemblage. Pp. 523–538. In: Wells, F. E., Walker, D. I., Kirkman, H. and Lethbridge, R. The Marine Flora and Fauna of Rottnest Island, Western Australia. Western Australian Museum, Perth.

Short, J. W. and Potter, D. G. 1987. Shells of Queensland and the Great Barrier Reef. Marine Gastropods. Golden Press, Drummoyne, NSW.

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